

**ANNUAL REPORT FOR
TREATABILITY STUDIES PROGRAM
FISCAL YEAR 1992**

ROCKY FLATS PLANT

**U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado**

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EXECUTIVE SUMMARY

This *Annual Report for Treatability Studies Program - Fiscal Year 1992* (FY 92) presents a summary of activities completed under the Environmental Restoration (ER) Treatability Studies Program at the Rocky Flats Plant (RFP). The ER Program provides coordination of site characterization activities, remedial investigations/feasibility studies (RI/FS), and remedial and/or corrective actions which address environmental contamination on a sitewide basis at RFP. The efforts described are conducted in accordance with the Inter-Agency Agreement (IAG) signed by the U. S. Department of Energy (DOE), the U. S. Environmental Protection Agency (EPA), and the Colorado Department of Health (CDH).

A Final Treatability Studies Plan (TSP) and an FY 91 Annual Report have been prepared prior to this FY 92 Annual Report. The purpose of the former two documents was to identify and evaluate the applicability of a wide variety of potential remediation treatment technologies to address contamination issues at RFP, and to provide for a status update of activities for each fiscal year, respectively. The Final TSP was prepared pursuant to the IAG, while the subsequent annual reports have been and will continue to be prepared in accordance with agreements outlined in correspondence between the EPA and DOE.

The FY 92 Annual Report provides: (1) an updated technology evaluation of potentially applicable treatment technologies; (2) a summary update of newly available environmental site characterization data from the Rocky Flats Environmental Database System (RFEDS); (3) a complete review of preliminary chemical-specific Treatability Study Benchmarks (TSBs); (4) a literature review to identify new and/or innovative treatment technologies; (5) a complete review of active and/or planned RFP treatability studies and interim measures/interim remedial actions (IM/IRA); and, (6) a screening and selection of potentially applicable treatment technologies for use at RFP in the future. Note that in the FY 91 Annual Report, item (3) above referred to the review of potential chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs). The change to referencing standards as preliminary chemical-specific TSBs was made in the FY 92 Annual Report since the chemical specific standards against which characterization data are reviewed are not currently designated as ARARs. Thus, the chemical-specific standards are more appropriately referred to as "benchmarks."

Two new treatment technologies were identified during completion of the FY 92 Annual Report. These include manganese dioxide adsorption and reverse burn gasification. Manganese dioxide adsorption is capable of isolating a variety of radionuclides in aqueous waste streams. Reverse burn gasification will destroy organic compounds in a wide variety of media.

Three other technologies initially evaluated in the Final TSP or FY 91 Annual Report were reevaluated in this report due to their potential for addressing RFP contamination issues. These reevaluated technologies include radio frequency (RF) heating, electrokinetic remediation, and supercritical carbon dioxide extraction. Radio frequency heating was reevaluated since it is currently under consideration for volatile organic compound (VOC) removal in soils at Operable Unit 1 (OU 1). Electrokinetic remediation was reevaluated due to recent evidence of its capability in mobilizing selected VOCs in soil. Supercritical carbon dioxide extraction was reconsidered due to its potential for removing various radionuclides and metals from soil. Of these three technologies, only RF heating passed the screening process for additional treatability testing. Detailed descriptions of all five treatment technologies are given in the report.

Related treatment activities ongoing at RFP described in this report include: OU 1 groundwater treatment under an IM/IRA; OU 1 proposed soils treatability studies; OU 2 surface water IM/IRA; OU 2 subsurface Interim Measures/Interim Remedial Action Plan (IM/IRAP); the current status of OU 4; water treatment using a colloid polishing filter; proposed oxidation/reduction (redox) processes treatability studies plan; plutonium in soils treatability studies plan; and colloidal and solution phase transport of plutonium and americium in groundwater.

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ACRONYMS

ARARs	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CTMP	Comprehensive Treatment and Management Plan
DOE	U. S. Department of Energy
ER	Environmental Restoration
EPA	U. S. Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FY	Fiscal Year
GAC	granular activated carbon
gpm	gallons per minute
GS	gravimetric separator
HGMS	High-Gradient Magnetic Separation
HMOs	Hydrous Manganese Dioxides
IAG	Inter-Agency Agreement
IHSSs	Individual Hazardous Substance Sites
IM/IRA	Interim Measures/Interim Remedial Action
IM/IRAP	Interim Measures/Interim Remedial Action Plan
LANL	Los Alamos National Laboratory
LDRs	Land Disposal Restrictions
LLM	low-level mixed
MCLGs	maximum contaminant level goals
MCLs	maximum contaminant levels
mg/L	milligram per liter

NTIS	National Technical Information Service
NTS	Nevada Test Site
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PCBs	polychlorinated biphenyls
pCi/g	pico curies per gram
pCi/L	pico curies per liter
R&D	research and development
RF	radio frequency
RFEDS	Rocky Flats Environmental Database System
RFP	Rocky Flats Plant
RI/FS	remedial investigation/feasibility studies
SARA	Superfund Amendments and Reauthorization Act
SNL	Sandia National Laboratory
SO	Systems Operation
SOW	Statement of Work
SVOCs	semivolatile organic compounds
TBC	to be considered
TDS	total dissolved solids
TIS	Technology Investment Strategy
TRB	triple-reverse-burn
TSB	treatability study benchmark
TSP	Treatability Studies Plan
USGS	U. S. Geological Survey
UV/peroxide	ultraviolet light and hydrogen peroxide
VISITT	Vendor Information System for Innovative Technologies
VOC	volatile organic compounds
WERL	Water Engineering Research Laboratory

The *Annual Report for Treatability Studies at Rocky Flats Plant - Fiscal Year 1992* (hereinafter referred to as the FY 92 Annual Report) summarizes activities directly associated with the Treatability Studies Program of the Rocky Flats Plant (RFP) Environmental Restoration (ER) Program. The ER Program at RFP coordinates the performance of environmental site characterization activities, remedial investigation/feasibility studies (RI/FS), and remedial and/or corrective actions for individual operable units (OUs) sitewide. The FY 92 Annual Report addresses the status of and the data compiled under RFP treatability studies for the period beginning October 1, 1991 and ending September 30, 1992.

Environmental contamination at RFP has been previously documented for selected individual OUs. Site characterization for the remaining OUs will begin in the future. The RFP Sitewide Treatability Study Program was initiated to identify and evaluate remediation treatment technologies potentially applicable to contaminants identified at more than one OU. This screening process was also used in the FY 92 Annual Report. In addition to identifying and reviewing potentially applicable treatment technologies not considered previously, the FY 92 Annual Report completes a review, reevaluation, and rescreening of relevant treatment technologies originally described in the Final Treatability Studies Plan (Final TSP) (EG&G 1991a) and/or the FY 91 Annual Report (EG&G 1992a). To supplement the technology review and status update for treatability study activities at RFP, recently collected site characterization data for the OUs have been reviewed and compared to preliminary chemical-specific Treatability Study Benchmarks (TSBs). TSBs are numerical concentrations published by various regulatory agencies and they may form the basis for evaluating Applicable or Relevant and Appropriate Requirements (ARARs). A preliminary chemical-specific TSBs review was necessary in order to ensure standards developed or under consideration since issuance of the FY 91 Annual Report were addressed. Brief discussions of each section on the report are provided below as additional background information to this report.

1.1 SITE CHARACTERIZATION DATA

Analytical site characterization data made available from the Rocky Flats Environmental Database System (RFEDS) since the FY 91 Annual Report were reviewed. The data review provided information with regard to: (1) the presence of potential contaminants at RFP not previously identified; and, (2) the presence of contaminants at concentrations differing from those previously detected (as reported in the Final TSP and FY 91 Annual Report). In addition, the RFEDS data includes new characterization data recently validated and/or corrected since the FY 91 Annual Report. As a result of this review, new contaminants and changes in both maximum and minimum

contaminant concentrations were identified for various media in five OUs. The contaminant summary data table from the FY 91 Annual Report was updated for this report.

1.2 PRELIMINARY CHEMICAL-SPECIFIC TSBs REVIEW

A review of potential Federal and State chemical-specific TSBs (i.e., Groundwater Quality Standards, Federal Surface Water Quality Standards, Statewide and Basin Surface Water Quality Standards, and Stream Segment Surface Water Standards) was completed for RFP. Revisions to the information presented in the FY 91 Annual Report were made based on a review of new analytical site characterization data from RFEDS and a review of State regulatory standards for groundwater and surface water. Preliminary chemical-specific TSBs for groundwater and surface water may be considered as preliminary remediation goals to be used in the RI/FS process for individual OUs. The preliminary chemical-specific TSBs given in this report will continue to be reviewed and possibly will be revised in subsequent Annual Reports as well as RI/FSs completed for individual OUs. The preliminary TSBs identified hereinafter are consistent with RFP's Potential Sitewide Table of "Benchmarks." The RFP chemical-specific "benchmarks" are specific standards that have been identified as the likely starting points for the development of ARARs in the sitewide context of remediation. The benchmark table was conditionally-approved by the Colorado Department of Health (CDH) in FY 92 pending incorporation of specific CDH comments for chemical-specific standards.

1.3 LITERATURE REVIEW

A review of various databases was completed to identify new, innovative, or emerging treatment technologies for consideration in the technology screening and selection process. The literature review also compiled new information regarding treatment technologies previously considered in the Final TSP and the FY 91 Annual Report, where appropriate.

1.4 TREATABILITY STUDIES

A summary was completed for ongoing treatability studies at RFP, as well as for active interim remedial actions, and for other information from research studies available subsequent to the FY 91 Annual Report. Planned treatability testing projects for individual OUs and the sitewide program are also discussed.

1.5 TECHNOLOGY SCREENING AND SELECTION

Technology selections completed in the Final TSP and the FY 91 Annual Report were reviewed and reevaluated based on currently available characterization data. Accordingly, modifications and/or additions to the previous reports are addressed in the FY 92 Annual Report. The review, evaluation, and screening were completed using the same process as in the Final TSP and the FY 91 Annual Report. The technology screening is provided in Appendix A of this document.

1.6 APPENDICES

Detailed background information was used to prepare the discussion and provide conclusions in this FY 92 Annual Report. This information is provided in the appendices for support purposes. Five appendices to the report include: (1) Appendix A - Technology Screening and Selection; (2) Appendix B - FY 92 RFEDS Data, and Preliminary Chemical-Specific TSBs for the Sitewide Treatability Studies Program; (3) Appendix C - Workplan for the Control of Radionuclide Levels in Water Discharges from Rocky Flats Plant, Annual Update; (4) Appendix D - Technology Data Summaries for Treatment Technologies Reviewed in the FY 92 Annual Report; and, (5) Appendix E - Statements of Work for Selected Technologies for Treatability Testing.

SUMMARY OF NEW CONTAMINANT DATA

A review of new analytical data from RFEDS was completed to evaluate additions and modifications to existing site characterization data on an OU-by-OU basis. Raw data were sorted by media for each OU where new data in FY 92 were available. Media for which data were available include groundwater, surface water, subsurface soils, surface soils, and sediments. New characterization data were provided for five OUs, including OU 1, OU 2, OU 3, OU 8, and OU 13. These are the same OUs for which new data were reviewed and summarized in the FY 91 Annual Report. Analytes must be found at concentrations greater than preliminary chemical-specific TSBs for a specific media in order to be considered in sitewide treatability testing studies. In addition to consideration under the sitewide treatability studies program, the constituents of concern identified at the individual OUs will be subject to a detailed ARARs analysis during the scheduled RI/FS process for that specific OU.

To update analytical data in the FY 92 Annual Report, maximum analyte concentrations reported in the FY 91 Annual Report were reviewed against new FY 92 maximum analyte values reported in RFEDS. Preliminary FY 92 analytical characterization data from RFEDS are provided from the five OUs for which data exist in Tables B-1 through B-5 of Appendix B. Table 2-1 summarizes the newly reported FY 92 maximum analyte concentrations from the RFEDS data given in Appendix B. This tabulated data provides the previous maximum reported concentration (i.e., from the FY 91 Annual Report), and compares these data to new maximum values for analytes detected during FY 92. It should be noted that these RFEDS data have not necessarily been validated to date. Such validation procedures must be completed prior to use of the data for risk assessment or engineering purposes at RFP. Data given in Tables B-1 through B-5 are sorted by OU and by medium.

Table 2-2 is an update of all maximum analyte concentrations at RFP, which was previously reported in the FY 91 Annual Report (i.e., Table 2-1 of the FY 91 Annual Report). This table reflects the new maximum analyte values presented in Table 2-1 of this report. The only analyte detected as part of FY 92 data collection activities that had not been previously identified in any media at RFP was 1,3-dichlorobenzene, which was detected in OU 1 soil. However, in some cases, an analyte was detected in a specific medium for the first time in FY 92. For example, beta-BHC (a common pesticide) was detected in FY 92 in OU 1 groundwater, but had been previously identified in surface water. As seen in Table 2-1, the greatest number of new maximum analyte concentrations were for soil samples in OUs 1, 2, and 8. These analytes consisted primarily of volatile and semivolatile organic compounds (VOCs and SVOCs, respectively).

Analytes detected in groundwater samples for the first time in FY 92 include: beta-BHC, diethyl phthalate, and benzoic acid. Analytes detected in soil samples for the first time in FY 92 include:

1,1,2,2-tetrachloroethane, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2-methylnaphthalene, and silicon. A discussion of the new maximum analyte concentrations for all media, and how they pertain to preliminary chemical-specific TSBs, is given in Section 3. A detailed ARARs evaluation of all analytes in each media will be made as part of the RI/FS process for individual OUs.

PRELIMINARY CHEMICAL-SPECIFIC TSBs REVIEW

This report contains an updated review of preliminary constituents of concern at RFP for FY 92, and takes into account any new TSBs identified during FY 92 (i.e., as of September 30, 1992). A summary of preliminary chemical-specific TSBs is presented in Tables B-6 through B-9 of Appendix B. The TSBs identified are consistent with RFP's *Sitewide Benchmark Tables and Analytical Methods Compendium* - December 1992. The RFP chemical-specific "benchmarks" are specific standards that have been identified as the likely starting points for the development of ARARs in the sitewide context of remediation. The benchmark table was conditionally-approved by the Colorado Department of Health (CDH) in FY 92 pending incorporation of specific CDH comments for chemical-specific standards.

Numerical values for preliminary chemical-specific TSBs at RFP have been updated from the FY 91 Annual Report based on a detailed review of Federal and State health environmental statutes and guidance. The chemical-specific TSBs utilized hereinafter are preliminary and are subject to change during the ARARs development process and as additional site-specific information becomes available during completion of the individual baseline risk assessments and site characterization investigations for the OUs.

Preliminary chemical-specific TSBs will factor into the ARARs determination process. In turn, an assessment of chemical contamination levels, volumes for treatment, and other factors such as individual project remedial action objectives will guide the development of treatability study plans. In this application, preliminary chemical-specific TSBs have been compared to sitewide maximum and minimum concentrations for a wide variety of analytes. Additionally, some sitewide maximum and minimum concentrations are compared to background concentration values. This is done to facilitate a preliminary screening of potential media (e.g., water, soil, etc.) and compounds that could be candidates for treatability studies. This preliminary screening is done by comparing maximum reported concentrations against the lowest numeric preliminary chemical-specific TSBs. This allows one to obtain a bounding case perspective of the possible candidate media and compounds for treatability studies.

The preliminary TSBs used to evaluate chemical concentrations include maximum contaminant levels (MCLs) for drinking water; Federal Ambient Water Quality Criteria (AWQC); and Colorado statewide, basinwide, and stream-segment standards for surface water and groundwater, including radionuclides. The Environmental Protection Agency (EPA) health-based risk assessment criteria for the ingestion of carcinogens and systemic toxicants in water (EPA 1989) are also used to evaluate chemical concentrations. For purposes of the FY 92 Annual Report, background concentrations (EG&G 1990) for soil and sediment were used as guidance in the preliminary chemical-specific TSBs evaluation. Risk assessment criteria and background concentrations will

be categorized as "to be considered" (TBC) in the regulatory sense during development of the RI/FS. Other TBC guidances include future effective maximum contaminant level goals (MCLGs), as these are not identified as preliminary TSBs. Future MCLs (standards to become effective in 1993 or 1994) are included, however, for consideration as preliminary TSBs.

As CERCLA investigations proceed for each OU, additional information will enable refinement of acceptable levels of constituents of concern at RFP based on risk assessment studies, as well as on established standards. The initial establishment of an acceptable level for specified contaminants occurs during development of remediation goals for the FS. Remediation goals defined in the FS allow focused development of candidate remedial alternatives.

The preliminary TSB values from Appendix B have been compared to maximum and minimum analyte levels detected in groundwater, surface water, soils, and sediments at RFP, as summarized in Table 2-2. As with the FY 91 Annual Report, the most stringent Federal or State standard (excluding MCLGs at zero) or health-based criterion for water was used as the preliminary TSB for surface water and groundwater. Where a given standard is below the analytical detection limit, the RFP detection limit was listed as the preliminary TSB. The lowest health-based risk criterion was used for chemicals which have no Federal or State standard, where available.

Maximum soil analyte concentrations presented in Table 2-2 are compared to available soil and sediment background concentrations at RFP unless otherwise specified. The preliminary TSB value for plutonium in soils or sediments was based on CDH Rules and Regulations Pertaining to Radiation Control. Preliminary TSBs for gross alpha and gross beta emissions from soils and sediments are also based on CDH requirements.

3.1 SUMMARY OF CONTAMINANTS AND COMPARISON TO TSBs

The following sections compare TSBs to maximum analyte concentrations by medium for the OUs in which analytical data were available. Results of the comparison are summarized in Table 2-2. Analytes which exceeded TSBs or background concentrations are discussed below.

3.1.1 Groundwater

Elevated levels (i.e., above preliminary TSBs) of inorganics, metals, VOCs, SVOCs, and radionuclides have been detected at various Individual Hazardous Substance Sites (IHSSs) within the OUs at RFP. Analytes which exceed preliminary TSBs in any OU are considered for sitewide treatability studies.

Maximum values in groundwater exceed several preliminary TSBs at RFP as shown on Table 2-2. The following inorganics exceeded preliminary TSBs: chloride, cyanide, sulfate, nitrate as N, and nitrate plus nitrite as N. Values for pH were both above (basic) and below (acidic) the preliminary TSB for pH. Also, total dissolved solids (TDS) concentration exceeded preliminary TSBs.

The VOCs exceeding TSBs include: 1,1-dichloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, carbon tetrachloride, methylene chloride, tetrachloroethene, trichloroethene, vinyl chloride, 1,2-dichloroethane, 1,2-dichloroethene, 1,2-dichloropropane, benzene, and chloroform. The compound 1,1-dichloroethane was detected in groundwater at RFP for the first time in FY 92; however, a State standard has not yet been established for this compound. In addition, there is no associated risk assessment value for 1,1-dichloroethane in the EPA guidance document (EPA 1989).

The SVOCs in groundwater identified in the FY 91 Annual Report as exceeding preliminary TSBs are bis(2-ethylhexyl-phthalate and N-nitrosodiphenylamine. Two additional SVOCs were identified in groundwater at RFP during FY 92: beta-BHC, and diethyl phthalate. No preliminary TSBs exist for these two organics. However, a risk assessment value (a TBC) is given in EPA's guidance (EPA 1989) only for diethyl phthalate. The maximum concentration of diethyl phthalate detected at RFP is below this guidance level.

Federal drinking water standards were promulgated during FY 92 for antimony, beryllium, and thallium. As a result, these metals now exceed preliminary TSBs. Other metals exceeding TSBs (and which were previously identified) in the FY 91 Annual Report are: aluminum, arsenic, cadmium, cobalt, copper, chromium, iron, lead, manganese, mercury, nickel, vanadium, selenium, and zinc. Silver also exceeds the preliminary TSB in FY 92 and exceeded the preliminary TSB in 1991, but was inadvertently excluded in the FY 91 Annual Report discussion.

The radionuclides which exceed preliminary TSBs are the same as were identified for FY 91. These include gross alpha activity, gross beta activity, radium-226, radium-228, strontium-90, tritium, and total uranium.

3.1.2 Surface Water

It should be noted that recent State regulations pursuant to statewide surface water numeric standards for organics declare any chemical for which a value is not specified, a zero level has been established. The result is that practical laboratory quantification limits are the preliminary TSBs.

The Final TSP and FY 91 Annual Report reported maximum inorganic chemical values in surface waters exceeding preliminary TSBs as follows: chloride, cyanide, sulfate, nitrate as N, and nitrate plus nitrite as N. Values for pH were both above (basic) and below (acidic) the preliminary TSB for pH. Also, total dissolved solids (TDS) concentration exceeded preliminary TSBs.

Manganese is the only inorganic in surface water which had a new maximum value from the previous year and which exceeds a preliminary TSB. Other metals exceeding preliminary TSBs as identified in the Final TSP and FY 91 Annual Report, are as follows: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, silver, thallium, and zinc.

The VOCs exceeding preliminary TSBs reported in the FY 91 Annual Report are: 1,1-dichloroethene, tetrachloroethene, carbon tetrachloride, trichloroethene, methylene chloride, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, 1,2-dichloroethene, chloroform, and vinyl chloride. There are no additional VOCs in surface water identified for the FY 92 Annual Report.

Two additional SVOCs are identified as exceeding preliminary TSBs for surface water during FY 92: atrazine and simazine. Beta-BHC is also identified as a compound exceeding preliminary TSBs and which was not identified in the FY 91 Annual Report (Beta-BHC apparently exceeded preliminary TSBs in 1991). These three compounds are added to the previous list of SVOCs identified for FY 91 which include: alpha-chlordane, di-n-butylphthalate, N-nitrosodiphenylamine, bis(2-ethylhexyl)phthalate, naphthalene, phenol, and polychlorinated biphenyls (PCBs) which exceeded preliminary TSBs in FY 91.

Radionuclides identified in the previous year as exceeding preliminary TSBs for surface water are the same for the FY 92 Annual Report. These radionuclides are americium-241, gross alpha, gross beta, plutonium-239 and plutonium-240, radium-226 and radium-228, tritium, and total uranium. Strontium-90 was also identified in FY 92 as exceeding a preliminary TSB, although it had exceeded the preliminary TSB in FY 91, but was inadvertently excluded from the FY 91 Annual Report discussion.

3.1.3 Soils and Sediments

Soil and sediment background concentrations at RFP reviewed and compared to chemical concentrations in Table 2-2 show numerous analyte values that exceed background values. Groundwater, surface water, soil, and sediment samples were collected at representative background (i.e., undisturbed) locations at RFP to quantify background concentrations of chemical and radiological parameters (EG&G 1990). The comparison can be used to assist with identifying potential contamination areas at RFP.

All metals detected in soil and sediment samples at RFP exceed background concentrations with the exceptions of aluminum, beryllium, cobalt, copper, iron, molybdenum, potassium, silver, and tin. Analytical results are not available for phosphorous, and background concentrations are not available for silicon. Limited background information is available for anions. Anions which exceed known background values at RFP are nitrate plus nitrite as N, and sulfide.

Oil and grease concentrations in soil exceed background concentrations. Radionuclides which exceed background concentrations in more than one OU are americium-241, strontium-89 and -90, uranium-233 and -234, uranium-235, uranium-238, plutonium-239 and -240, gross beta activity, and gross alpha activity.

Background concentrations in soils are not available for most of the organics. Semivolatile organics for which background concentrations are available and which exceed these concentrations are benzoic acid, bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, 4-chloro-3-methylphenol, chrysene, diethyl phthalate, di-n-butyl phthalate, fluoranthene, 1-nitrosodiphenylamine, phenanthrene, pyrene, and aroclor-1254 (a PCB). There are no background concentrations available for organics in sediments at this time.

LITERATURE SEARCH AND REVIEW

A literature search of newly available or recently published materials was conducted for purposes of compiling and reviewing potentially applicable remediation treatment technologies for contamination issues at RFP. The Dialog Database System was used to access five databases which potentially contain relevant citations pertaining to remediation treatment technologies. This is similar to the approach used in the FY 91 Annual Report. Databases accessed through Dialog included:

- Enviroline
- Pollution Abstracts
- Compendex
- National Technical Information Service (NTIS)

This literature search was used to strengthen information concerning potential remediation technologies previously compiled. Key words used for the database search were obtained by a thorough review of available EPA technology databases, as well as recent EPA and Department of Energy (DOE) publications on standard and innovative environmental remediation treatment technologies. Technology databases and other publications reviewed to assist in developing a list of key words included:

- Vendor Information System for Innovative Technologies (VISITT), U.S. EPA Technology Innovation Office
- Water Engineering Research Laboratory (WERL) Treatability Database System, U.S. EPA Risk Reduction Engineering Laboratory
- Innovative Treatment Technologies, Overview and Guide to Information Sources, U.S. EPA Office of Solid Waste and Emergency Response (OSWER), October 1991 (EPA 1991a)
- The Superfund Innovative Technology Evaluation Program: Technology Profiles, Fourth Edition, U. S. EPA OSWER, November 1991 (EPA 1991b)
- Remedial Action, Treatment, and Disposal of Hazardous Waste, Proceedings of the Seventeenth Annual RREL Hazardous Waste Research Symposium, U.S. EPA Office of Research and Development, April, 1991 (EPA 1991c).

Key words used in the database search were:

- Radio Frequency Heating
- Reverse-Burn Gasification
- Manganese Dioxide Adsorption
- Electro-Osmosis
- Radionuclides
- Transuranic
- Organic Contamination
- Metal Contamination

These key words were combined as appropriate for the database search process.

This review for key word identification was completed in conjunction with a detailed review of those treatment technologies previously identified in the Final TSP and the FY 91 Annual Report. Since these two previous documents have provided an extensive list of potentially applicable treatment technologies for screening evaluation, a relatively small number of new potentially applicable technologies were anticipated for the FY 92 database search.

The FY 92 Dialog Database search yielded approximately 125 citations for review. Abstracts were printed and reviewed for each citation. Useful references related to specific treatment technologies of interest were obtained and used in part to prepare the treatment technology descriptions provided in Appendix D of this report. Copies of citations listed for the technology descriptions given in Appendix D are contained in project files. Only two potential treatment technologies were newly identified during the FY 92 literature review process: manganese dioxide adsorption, and reverse burn gasification. No new information was discovered during the literature search related to treatment technologies previously rejected in the Final TSP or the FY 91 Annual Report. The screening process used to evaluate these technologies is presented in Appendix A.

TREATABILITY STUDY PROJECTS

A variety of treatability studies and interim remedial treatment actions have been proposed or are in progress at RFP. A summary of proposed, recently completed, and ongoing activities and of results to-date has been prepared. This summary serves as a status report for the various activities which have taken place during FY 92, and for the various related activities planned for FY 93.

To date, treatability and remedial treatment activities have been initiated for OUs 1, 2, and 4. These activities, which will continue into FY 93, are discussed in separate sections below. No treatability activities are planned for other OUs in FY 93. A Final Work Plan for Control of Radionuclide Levels in Water Discharges from the Rocky Flats Plant (EG&G 1992b) was prepared in addition to the Annual Report during FY 92. The work plan describes sampling methods, analytical protocols, methods, and limitations for determining radionuclide levels, summarizes statistical assessments of analytical results, and presents recommendations for additional radionuclide studies to characterize RFP discharge water quality. An update of this work plan will continue to be prepared on an annual basis and will include updates on the control of radionuclide releases, a water quality assessment, analytical techniques used for the water quality assessment, and treatment evaluations and proposals. The FY 92 update of this work plan is included as Appendix C, and is intended to complement information presented in the FY 92 Annual Report.

5.1 OPERABLE UNIT 1 ACTIVITIES

Operable Unit 1 is located at the 881 Hillside and is comprised of 11 IHSSs. Treatability and remedial treatment activities were initiated for groundwater at OU 1 during FY 92. An IM/IRA for groundwater collected from the French Drain system began treatment operation in FY 92. Treatability work for OU 1 soils (surface and subsurface) was proposed but not initiated in FY 92. Selected subsurface soil samples from IHSS 119.1 at the 881 Hillside were collected for treatability testing in FY 93. These two separate activities are discussed below.

5.1.1 Groundwater IM/IRA

Bench-scale treatability tests were conducted for VOC-contaminated groundwater at OU 1 during FY 91 (EG&G 1992a). These tests examined the effectiveness of oxidizing VOCs with ultraviolet light and hydrogen peroxide (UV/peroxide). Test results were favorable and were used for optimization of a full-scale treatment system for groundwater collected in the French Drain system located at OU 1. Operation of the full-scale treatment system began in April 1992.

The following information regarding the full-scale operation was summarized from discussions with the OU 1 Interim Remedial Action Site Manager (personal communication, EG&G 1992c). A total of approximately 540,000 gallons of groundwater was collected in the OU 1 French Drain system and treated through FY 92. The treatment system is comprised of a UV/peroxide unit operation followed by ion exchange and finally a deaerater to remove carbon dioxide generated in the ion exchange beds. Treated effluent is pH adjusted, and temporarily stored in order to verify effective VOC removal prior to discharge to the south interceptor ditch. A process flow schematic of the OU 1 groundwater treatment train is given in Figure 5-1.

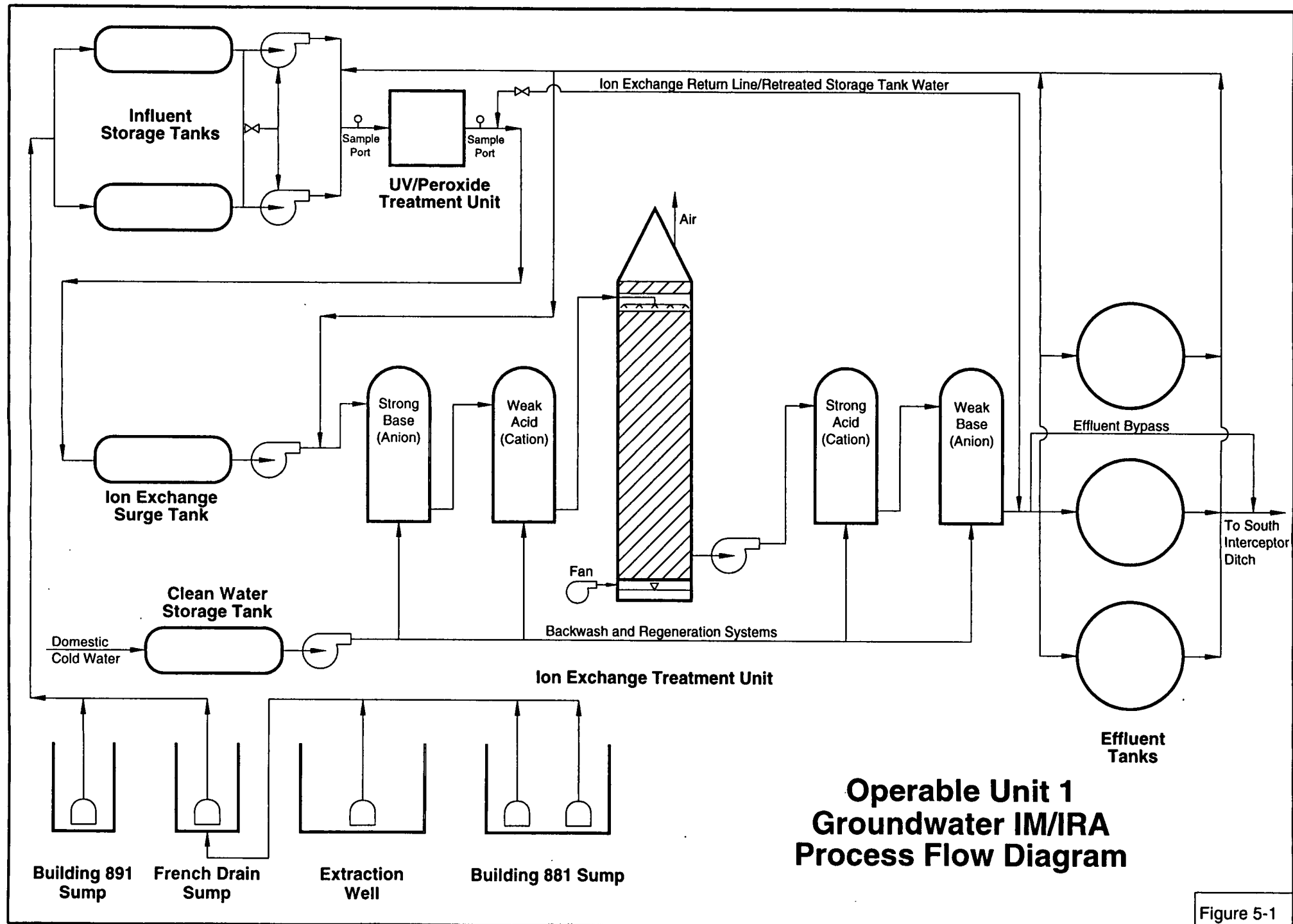
System operation has been intermittent since its inception in April 1992, due to inflow variations to the French Drain system. The French Drain is equipped with a sump system which uses standard centrifugal pumps to direct collected groundwater to the treatment plant. High and low level switches in the sump system allow for automated pumping operation. The French Drain was designed to maintain a line sink for groundwater flowing away from the 881 Hillside area.

Two tanks are located at the upstream side of the treatment system to store influent. Average flow rates are approximately 30 gallons per minute (gpm); however, the treatment plant is only operated on an intermittent basis. A total of eight UV lamps are normally in use for the average 30-gpm flow rate. A 35- to 50-milligram per liter (mg/L) dose of hydrogen peroxide is fed directly to the UV reaction chamber, where organic compounds are oxidized.

Discharge from the UV/peroxide process enters a surge tank for temporary storage and for flow equalization upstream of the ion exchange and deaeration processes. Two ion exchange reactors are located upstream of the deaeration column—one a strong base and one a weak acid reactor. The deaeration column is used to remove gases that may otherwise tend to come out of solution in the final two ion exchange reactors, which could cause process short circuiting in the resin beds. Flow then enters strong acid, then weak base ion exchange reactors.

Table 5-1 shows the ion exchange resin types and contaminants treated in each of the reactors. The resins from Columns 2 through 4 are regenerated after approximately 55,000 gallons of treated water pass through the system. Both acid and caustic regeneration solutions are used; spent solution is directed to the Building 374 evaporator. Approximately 3,000 to 4,000 gallons of the solution are used for each regeneration cycle. Upon regeneration, the effluent pH from Column 4 rises to approximately 13, but subsequently decreases gradually.

Effluent from the treatment process is directed to the 150,000-gallon storage tanks for confirmation of VOC removal prior to discharge into the south interceptor ditch. The storage tanks are lined with an epoxy coating to prevent corrosion. Shortly after treatment began at the facility, selected water samples obtained from the storage tanks contained low concentrations of xylenes and ethylbenzenes. This was likely due to the epoxy tank lining since neither of these compounds



had been detected in untreated influent. As a result, the stored water from final storage has, in some cases, been redirected to the OU 1 UV/peroxide process for further treatment. At other times the UV/peroxide process generated effluent with pH levels too low for direct discharge; this effluent would then be retreated through the ion exchange and deaeration system which had the effect of raising the pH to a range of 7 to 7.5 prior to its final discharge.

The three 150,000-gallon effluent storage tanks were sized to provide sufficient storage volume to allow for final effluent analytical testing, assuming a 10-day turnaround time for laboratory results. To date, no problems have been encountered with storage capacity; however, if seasonal inflow to the French Drain system increases significantly, available storage capacity due to the aforementioned analytical requirement may be exceeded.

A preliminary *Draft Systems Operation (SO) and Optimization Test Report* (EG&G 1992d) was prepared to present test results and data summaries with regard to the performance of the UV/peroxide treatment system, as well as to provide recommendations for treatment system improvements and modifications for process optimization. The SO report contains all significant details of the OU 1 IM/IRA treatment system operations. Analytical results of treatment system influent from the French Drain indicate the presence of the following analytes on a consistent basis:

- Organics - tetrachloroethene, and trichloroethene
- Radionuclides -uranium-234, -235, -238, tritium, gross alpha, and gross beta
- Inorganics - arsenic, barium, calcium, copper, iron, lithium, magnesium, potassium, selenium, sodium, strontium, zinc, bicarbonate, chloride, fluoride, nitrate, sulfate, and TDS.

However, of these analytes, only tetrachloroethene, trichloroethene, selenium, and TDS exceeded preliminary TSBs. The UV/peroxide system was successful in oxidizing the organics to below analytical detection limits. The ion exchange system was successful in removing the radionuclides, as well as the inorganics. Summary data supporting the treatment success of the system is given in Tables 5-2 and 5-3. Table 5-2 gives influent and effluent concentrations of tetrachloroethene, and trichloroethene and their corresponding removal efficiencies through the UV/peroxide system. Table 5-3 provides influent and effluent concentrations of metals and inorganics and their corresponding removal efficiencies through the ion exchange system.

Several recommendations to improve the current treatment system are provided in the SO report, and are summarized below:

- Consider direct discharge of treated effluent to the south interceptor ditch, bypassing effluent storage tanks to eliminate double treatment of groundwater. The tank coating contains residual organics that may dissolve into the stored effluent. An online analyzer would verify the treated effluent meets discharge requirements.
- Install a shunt trip on the secondary side of the UV/peroxide system ballast for automatic system shut down in the event that arcing occurs in the secondary lamp circuit.
- Improve cooling in the UV/peroxide system ballast enclosures to prolong service life of ballasts and capacitors. The cooling could be achieved by installing internal fans or relocating the existing fans.
- Install a cartridge filter on the inlet side of the UV/peroxide system feed pumps to remove solids.
- Evaluate ion exchange resins to eliminate wide pH swings.
- Consider converting ion exchange column No. 1 to a regenerable column.
- Install a gamma spectrometer analyzer in the ion exchange system effluent line for online analysis.
- Modify the UV system discharge piping to maintain a constant and reliable flooded suction at the peroxide splitter pump inlet.
- The french drain water level should be maintained at an intermediate level to avoid impacting groundwater recovery and possible silt transport.
- Possibly split flow after ion exchange column No. 2 to minimize pH variation, while maintaining effluent quality to meet potential ARARs and reducing the ion exchange regenerant. A study of flow splitters and alternative ion exchange resins should be conducted to evaluate these possibilities.
- Conduct additional analyses on the 881 footing drain stream to confirm that the stream meets potential ARARs before treatment.
- Continue evaluation of iron concentrations to confirm whether it interferes with the ion exchange process.

- Continue monitoring ion exchange column No. 1 to evaluate resin effectiveness and radionuclide loading (health and safety concerns).
- The acid and caustic pump discharge piping from Column 1 was observed to vibrate. Additional pipe support should be placed to protect the piping from vibration damage.

The recommendations given in the SO report were based on operational performance data for the UV/peroxide system. Implementation of any of the recommendations listed should include a detailed engineering review of the potential merits of each recommendation. Continued treatment performance will be reported in the FY 93 Annual Report.

5.1.2 Soils Treatability Testing

As part of the OU 1 RI/FS currently being conducted, selected soil samples from IHSS 119.1 at the 881 Hillside were collected for treatability testing. The samples were collected and submitted to IT Corporation in Knoxville, TN for the treatability work. Sample collection was completed in accordance with the approved treatability study work plan (which includes a Field Sampling Plan) prepared for OU 1 (EG&G 1992e). However, characterization of the untreated soil samples collected indicated that trace contamination was present, but there were no significant levels of contamination in the sample intervals examined, including those intervals that were suspected to have been saturated with contaminated groundwater. Thus, the treatability study effort was halted. Given the proximity of the sampling locations to the well 4387, a monitoring well in IHSS 119.1 that has had elevated concentrations of organic solvents in groundwater, it was reasonable to assume that contaminated soils would be retrieved. There is the possibility that the sampling effort confirmed the suspicion that the extent of subsurface soil contamination is very limited in the IHSS.

5.2 OPERABLE UNIT 2 ACTIVITIES

Operable Unit 2 is comprised of the 903 Pad, Mound Area, and East Trenches, as well as several other smaller IHSSs. Waste management practices in the past at OU 2 have included solid and liquid waste disposal, reactive metals destruction, and waste burning (EG&G 1992f). A formal RI is currently being prepared for OU 2. However, prior to completing the OU 2 RI and initiating the FS, two IM/IRAs have been initiated for surface water, groundwater, and subsurface soil. These IM/IRAs are described separately.

5.2.1 Surface Water IM/IRAP

A final Interim Measures/Interim Remedial Action Plan (IM/IRAP) was prepared, dated March 8, 1991 to address potential surface water contamination in the South Walnut Creek drainage within OU 2 (EG&G 1992f). The intent of this action was to minimize contaminant migration downgradient from OU 2 and RFP prior to completing the formal RI/FS process. Contaminants in Walnut Creek include VOCs (1,2-dichloroethene, carbon tetrachloride, tetrachloroethane, and trichloroethene), metals (aluminum, iron, and strontium), and radionuclides (plutonium-239 and americium-241). Potential interim remedial alternatives were analyzed; the recommendation was made for implementing a field treatment system comprising chemical precipitation, coagulation, membrane filtration, and granular activated carbon (GAC) (EG&G 1992f). A field treatment program was divided into two phases as described below.

Phase I involved implementing a surface water collection system and GAC treatment for VOC removal. The Phase I operation was started in May 1991 and completed in early 1992. Figure 5-2 shows the Phase I process flow schematic for the OU 2 surface water treatment system. Two surface water collection stations were constructed for the Phase I operation. The collection basins were constructed of pre-cast concrete and were fitted with float-controlled submersible pumps. Influent was directed to a 10,000-gallon flow equalization tank prior to bag filtration. The bag filters were operated in parallel for sediment removal prior to GAC treatment. Two GAC units were operated in a rotating lead and polish mode; the lead unit was taken out of service either by estimating an approximate contaminant breakthrough time based on design data, or if head loss became significant. Backwashing the lead GAC unit was performed by directing flow to the polish unit and using this treated effluent as the upflow stream in the lead unit. The GAC units were normally operated in series, except when in the backwash mode, where the polish unit provided the backwash source water. All backwash water was recycled to the flow equalization tank.

Phase II of the IM/IRAP consisted of adding chemical precipitation, coagulation, and membrane filtration unit operations upstream of the GAC treatment. Phase II treatment was designed to remove radionuclides, metals, and suspended solids, in addition to VOCs. The Phase II treatment operations began April 27, 1992. Figure 5-3 shows the Phase II process flow schematic for the OU 2 surface water treatment system. The surface water collection system installed for Phase I remained unchanged for Phase II operation. Flow from the 10,000-gallon equalization tank is directed to a set of two flash mix reaction tanks. Iron salt and sulfuric acid are added in Reaction Tank No. 1, and the pH is reduced to approximately 4.0. Flow continues to Reaction Tank No. 2, where lime is added to raise the pH to approximately 9.5 for metals precipitation. This stream flows to a solids concentration tank. Supernatant from the solids concentration tank flows through the microfilters (0.1-micron pore size); filtrate continues to a neutralization tank, where acid addition lowers the pH to the neutral range. Solids from the concentration tank are pumped to a sludge holding tank. The neutralized filtrate enters the GAC system; the rotating lead/polish

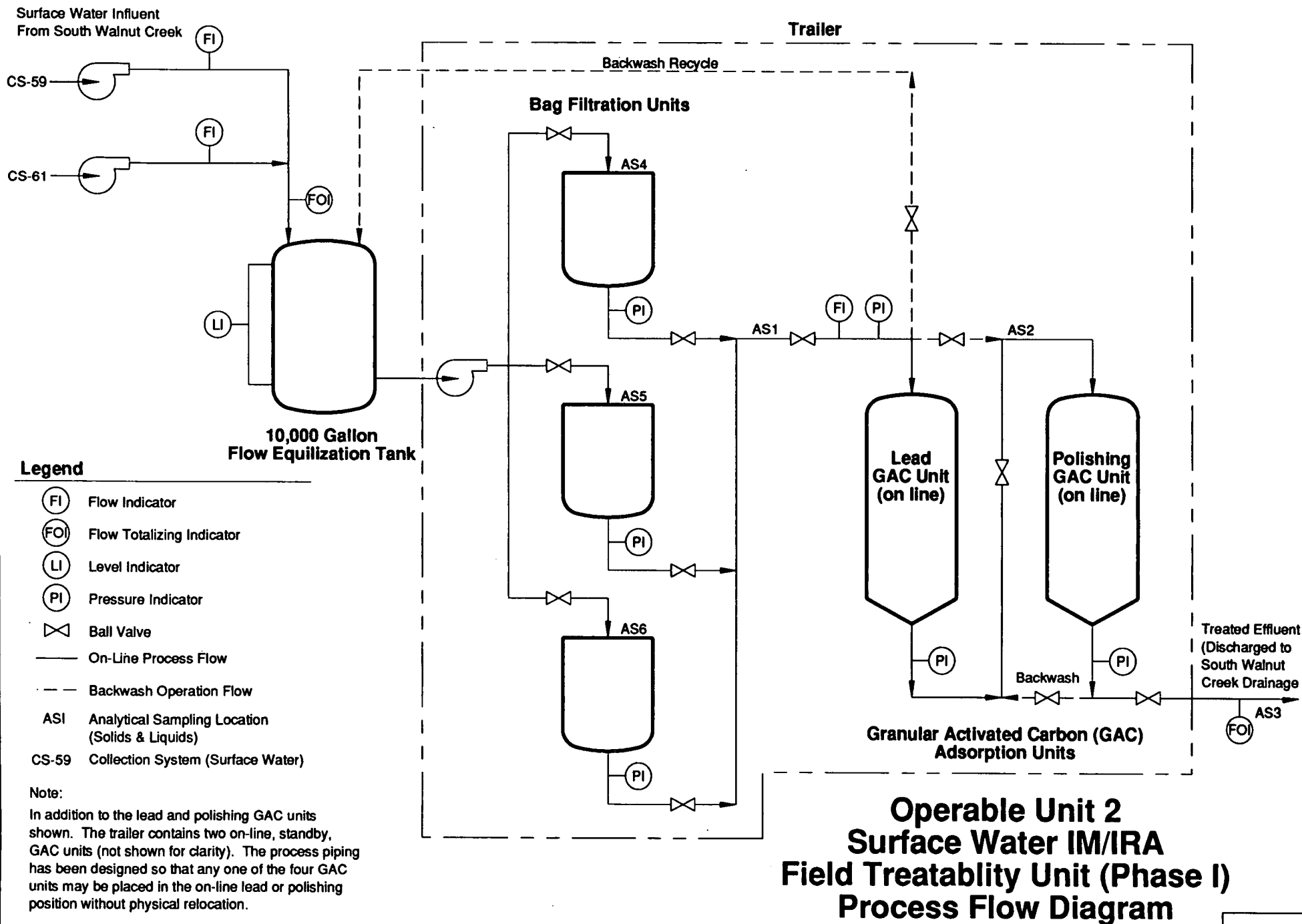


Figure 5-2

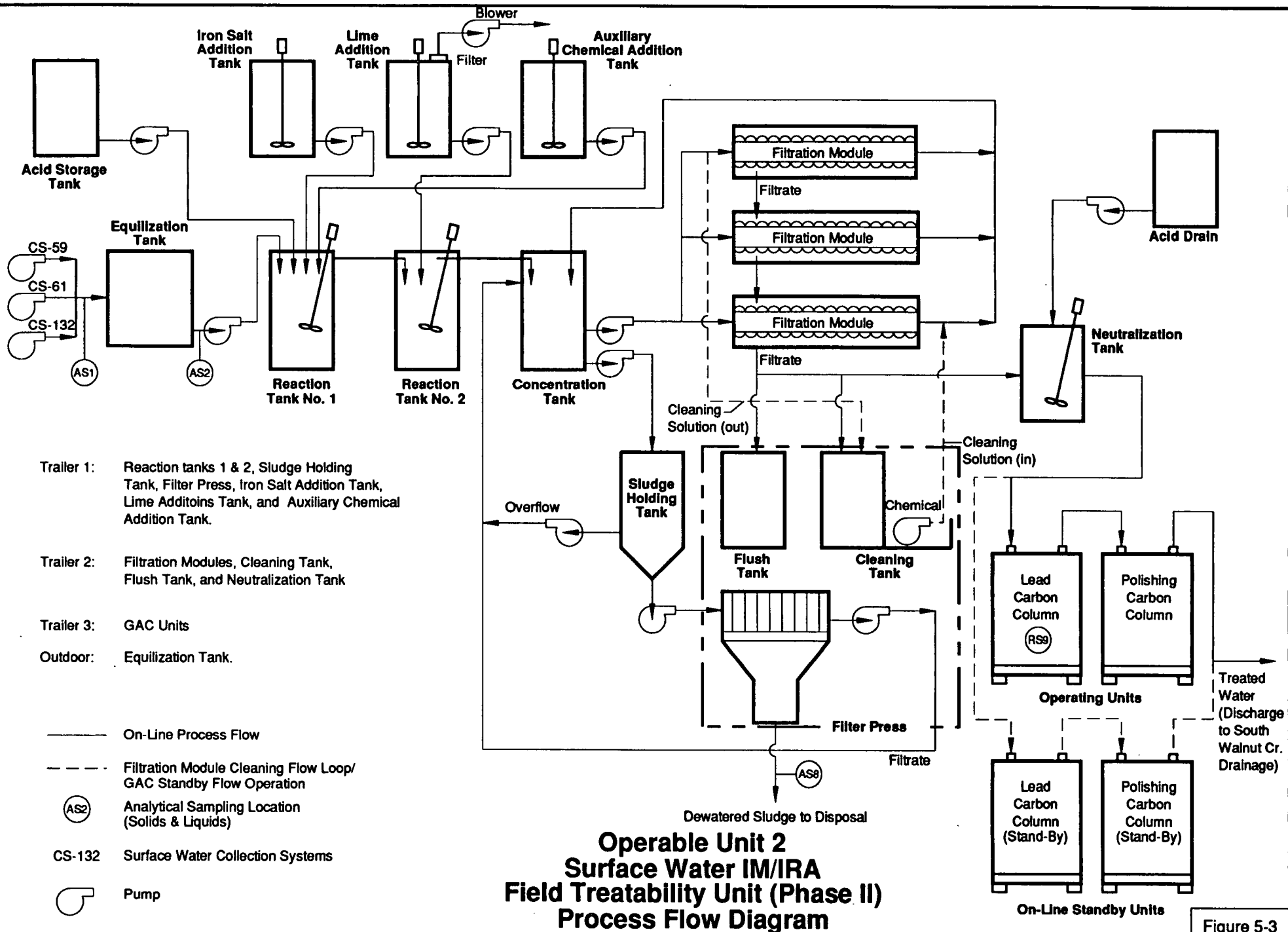


Figure 5-3

treatment mode for the GAC system is the same operation as used in Phase I. Sludge holding overflow is directed back to the solids concentration tank, while the sludge is directed to a filter press for dewatering. Dewatered sludge is drummed for temporary storage and analytical testing prior to proper disposal. Filtrate is returned to the solids concentration tank.

Available data from the Phase I operation indicate successful system performance for VOC removal (EG&G 1992f). Pertinent Phase I data were summarized in the OU 2 field treatability report for 1,2-dichloroethane. Table 5-4 gives influent and effluent data for 1,2-dichloroethane through the GAC treatment system for a selected period of the Phase I testing operation. This compound is generally regarded as the most difficult to remove of the organics present in the surface water. Results shown in Table 5-4 indicate the preliminary TSB for 1,2-dichloroethane was met or exceeded six times.

During Phase I operations, numerous difficulties were encountered with sediment loading and fouling of the GAC treatment system. The bag filters installed upstream of the GAC system did not provide consistent influent sediment and turbidity removal. As a result, the GAC units were subject to adverse solids loading which at times caused excessive head loss, inefficient adsorption, and channeling of the process stream through the units. Design of the GAC units was not based on allowing for backwashing to remove trapped sediment (e.g., they did not include internal distributors nor provide freeboard). Backwashing performed during Phase I resulted in little or no carbon bed expansion, resulting in poor sediment removal efficiency. Filter bags were used for Phase I sediment removal. Three sizes of filter bags, 1-micron, 5-micron, and 10-micron, were evaluated for performance. The 1-micron and 5-micron size bags became fouled too quickly for practical use. Additional problems were especially evident during or immediately following precipitation events. The 10-micron bags were most effective, although frequent changeout of these bags was also required.

In addition to information on the organics, analytical data for effluent quality from the treatment system suggest that radionuclides were not present in concentrations above the current preliminary chemical-specific TSB levels. No validated analytical data are currently available for the Phase II operation; however, preliminary data generated to-date suggest that preliminary chemical-specific TSB levels are not exceeded for most analytes in the treatment plant surface water influent (EG&G 1992g, personal communication). Phase II data will be reported and evaluated in the FY 93 Annual Report.

The Phase II operation has encountered several problems. The first problem encountered was related to the cleaning solution for the membranes. Originally, a sodium hypochlorite solution was used weekly with a monthly treatment of sulfuric acid. The treatment procedure proved to be ineffective after a couple of months. A cleaning solution of hydrogen peroxide and sulfuric acid was developed with help from the vendor and the membrane manufacturer. Cleaning with the

peroxide/sulfuric acid solution has been successful and is required once every two weeks. The sodium hypochlorite solution also caused corrosion of the welds on the GAC Cyclesorb units. This resulted in several pinhole leaks in the welds that will be repaired by the vendor at a later date.

Power generation has been a problem because power is not available at the site. The generator requires frequent routine maintenance and fueling. Power demands vary seasonally with peak demands during the winter months when power is needed to supply the heat tracing on water pipes. Lowest rates are during seasonal low flows of late summer and fall. The variability in power demand between peak and low level lends difficulty to supplying the power required throughout the year with a single generator.

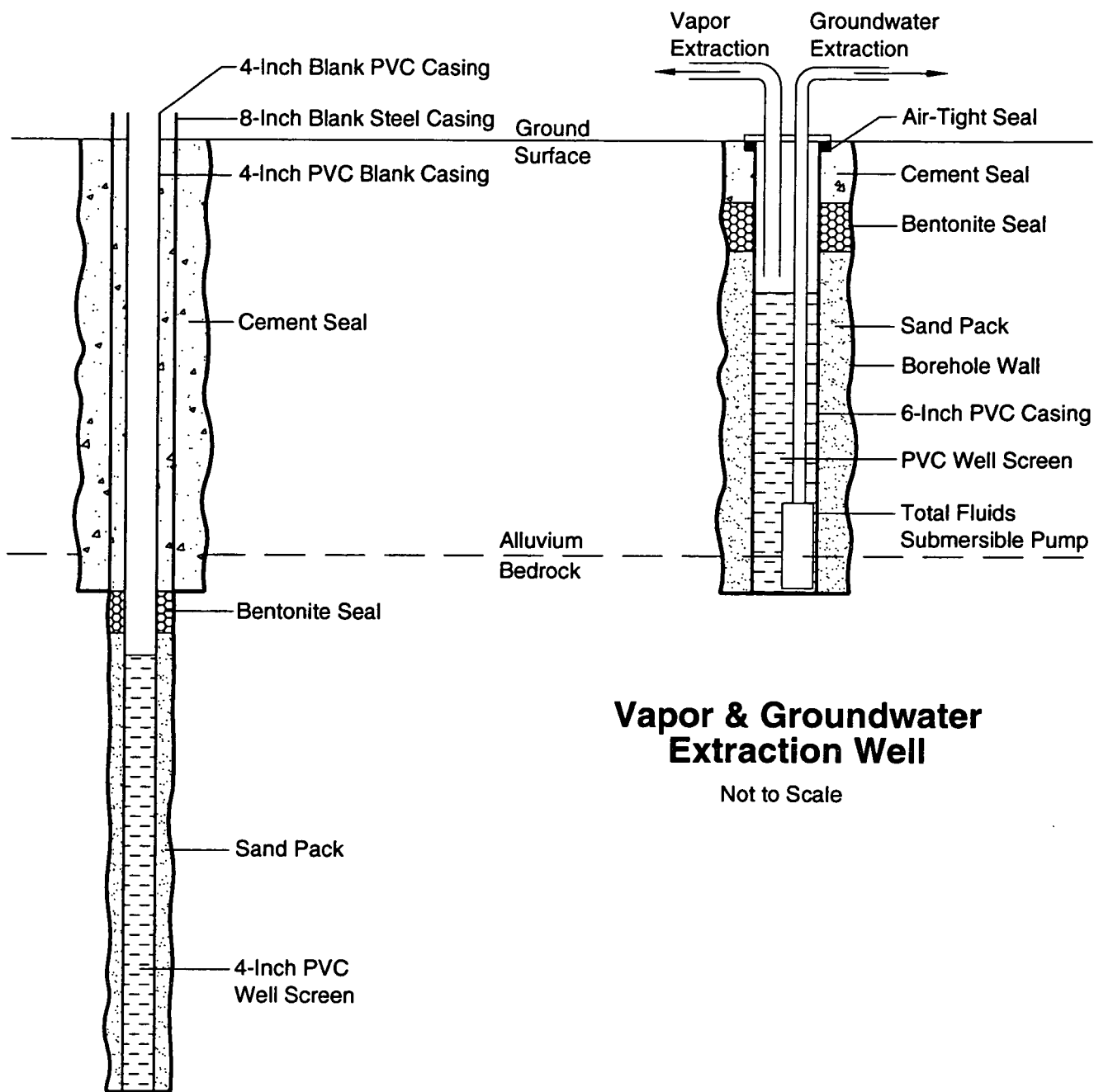
No problems with excessive head losses or channeling in the GAC operation have been noted due to sediments since Phase II treatment began.

5.2.2 Subsurface IM/IRAP

A Subsurface IM/IRAP was finalized and submitted for final agency review in FY 92. The IM/IRAP for OU 2 subsurface soils outlines proposed field- and pilot-scale testing of in situ vacuum-enhanced vapor extraction for soils beneath 903 Pad, Mound, and the East Trenches. Data generated will be used for evaluating the technology effectiveness, implementability, and potential environmental impacts at these three areas of OU 2. This evaluation can then be used in support of planned RI/FS activities if vapor extraction is being considered as a large-scale treatment option. Data generated through the proposed program will include: VOC mass recovered per unit cost, VOC mass recovered per unit time, area of influence of the vapor extraction system at each location, and overall ability to control VOC migration and aquifer dewatering.

Final site characterization work for the OU 2 subsurface will be completed during FY 93 to support preparing the bid package and design for pilot-scale treatability testing. The characterization work will include completing a soil vapor survey, and a soil boring and analytical testing field program. The bid package and design documents are scheduled for completion in FY 93. Final characterization results will be reported in the FY 93 Annual Report.

Details of the proposed in situ vacuum extraction for OU 2 are provided in the IM/IRAP (EG&G 1992h). A summary of relevant information is provided here for review. Vapor extraction will be accomplished in wells designed specifically for vapor extraction, and in wells having the dual purpose of groundwater and vapor extraction. A schematic of these two types of wells is shown in Figure 5-4. In addition to the extraction wells, the pilot-scale tests will use selected wells for



Vapor & Groundwater Extraction Well

Not to Scale

Vapor Extraction Well

Not to Scale

Operable Unit 2 Subsurface IM/IRA Vapor & Groundwater Well Schematics

ambient and heated air injection to enhance VOC recovery in the subsurface. Figures 5-5 and 5-6 show flow schematics of the proposed vapor extraction and injection systems, respectively.

5.3 OPERABLE UNIT 4 ACTIVITIES

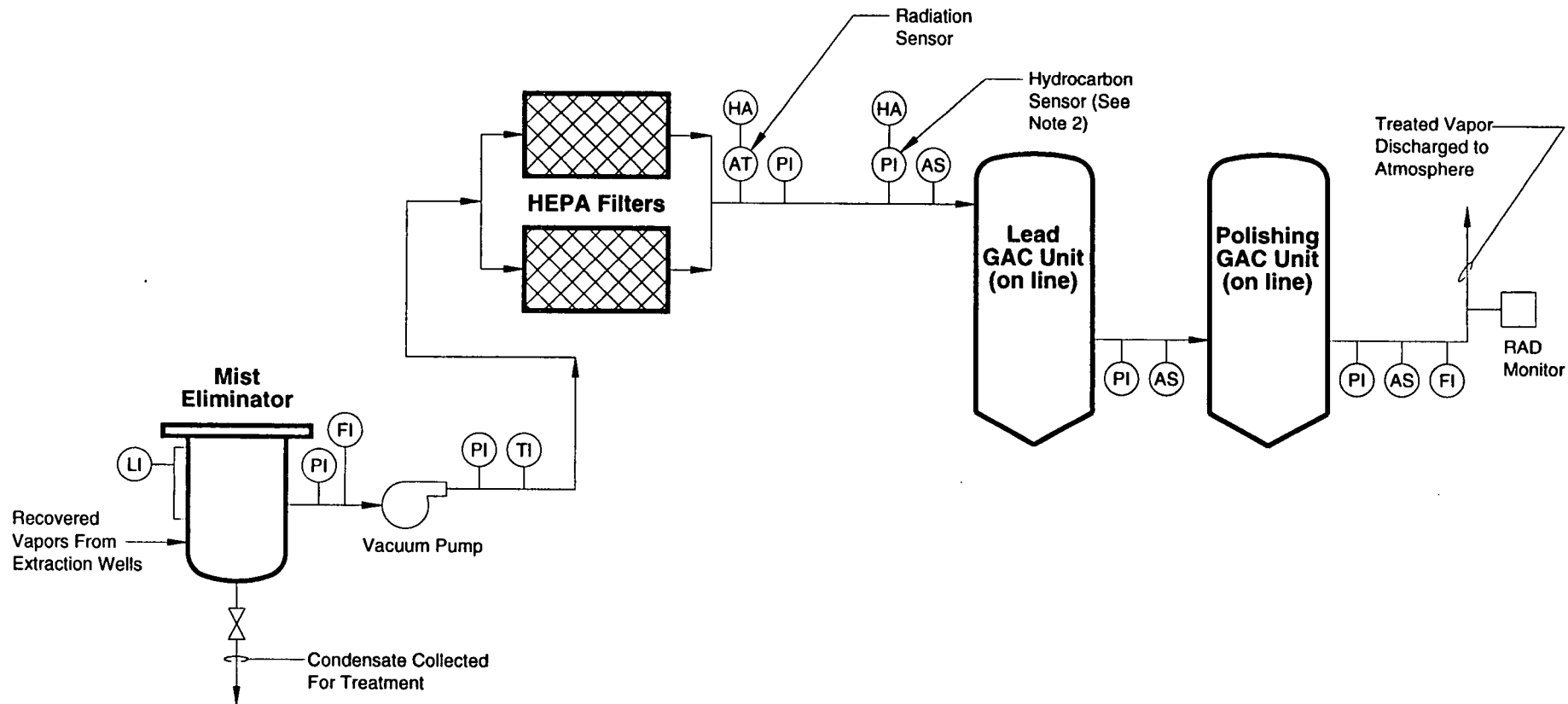
Preliminary treatability work is being performed at OU 4 related to treatment and stabilization of the solar pond salts. At this time no work plan has been prepared and no schedule has been secured.

5.4 COLLOID POLISHING FILTER TESTING

As reported in the FY 91 Annual Report, the Colloid Polishing Filter Method was tested for treatment effectiveness in removing uranium, plutonium, and americium from groundwater samples obtained at the OU 4 interceptor pump house. Results obtained in FY 91 proved favorable for metals and radionuclide removal. However, data collected during FY 91 were not provided in the FY 91 Annual Report, and are summarized below. The Colloid Polishing Filter Method removes metals and radionuclides in a two-step process: (1) prefiltration of bulk solids in influent; and, (2) sorption and chemical complexation of contaminants in a filter bed of insoluble oxide, silica, and quartz materials. The filter material has an affinity for metals, and for chelated and complexed metals, including radionuclides.

Eight experimental test conditions which varied the influent pH and the retention time in the filter polishing apparatus, and provided additions of different reducing agents were run (Laul, et al. 1992). The eight experimental conditions can be summarized as follows:

- (1) No pretreatment to influent - control conditions.
- (2) pH set to 8.0 using sodium sulfide.
- (3) pH set to 9.0 using sodium sulfide and sodium bisulfite.
- (4) pH set to 9.0 using sodium sulfide.
- (5) pH set to 8.0 using sodium sulfide and sodium bisulfite.



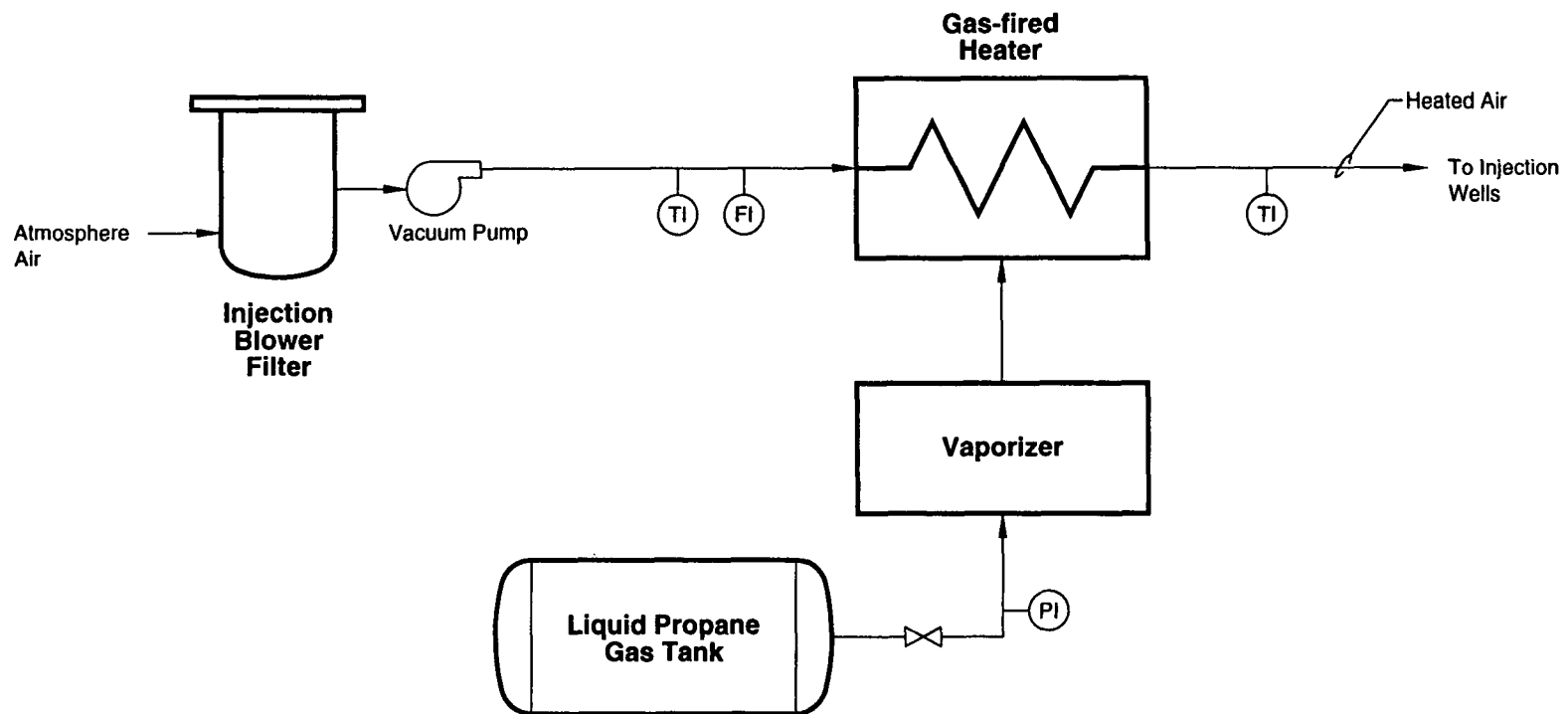
Legend

(FI)	Flow Indicator	(AT)	Analytical Transmitter
(AS)	Analytical Sampling Location	(HA)	High Alarm
(LI)	Level Indicator	(TI)	Temperature Indicator
(PI)	Pressure Indicator	⋈	Ball Valve

Notes:

- (1) Vapor injection equipment is mounted on a flatbed trailer for ease of transport to each pilot test site.
- (2) Hydrocarbon sensors are placed downstream of the vacuum pump in the secondary containment cavities of the process piping as necessary to monitor for VOC-contaminated vapor leaks.

Operable Unit 2 Subsurface IM/IRA Field Treatability Unit (Phase I) Vapor Extraction System



Legend

- (FI) Flow Indicator
- (TI) Temperature Indicator
- (PI) Pressure Indicator
- ⊗ Ball Valve
- On-Line Process Flow

Note:

Vapor injection equipment is mounted on a flatbed trailer for ease of transport to each pilot test site.

Operable Unit 2 Subsurface IM/IRA Field Treatability Unit (Phase I) Vapor Injection System

Figure 5-6

- (6) pH set to 9.0 using sodium sulfide and sodium bisulfite, and tested at two flow rates of 75 mL/min and 460 mL/min.
- (7) pH set to 9.0 using sodium sulfide and sodium bisulfite, and the minerals goethite and hematite added.
- (8) Overnight equilibrium allowed to be achieved with the Filter Flow-1000 media, and sodium sulfide added as a reducing agent.

Results of this bench-scale testing are given in Table 5-5. The sample collected from OU 4 had concentrations of uranium-238, 32 pico curies per liter (pCi/L), and uranium-234, 52 pCi/L. In addition, the sample was spiked with plutonium-239 at a concentration of 26.4 pCi/L and with americium-241 at a concentration of 22.2 pCi/L. Reducing agents were added to achieve a desired oxidation state of the radionuclides prior to the filter polishing process. In addition to evaluating removal effectiveness for the radionuclides, various metals were also examined in the effluent. Results for metals removed indicated that little or no removal through sorption occurred for barium, potassium, sodium, and strontium. However, aluminum, calcium, copper, iron, magnesium, manganese, and zinc were effectively removed by sorption, co-precipitation, and precipitation of hydroxides and sulfides.

Under the given test conditions, radionuclide removal results indicated that uranium-238, uranium-234, plutonium-239, and americium-241 were all effectively removed from the influent stream by factors ranging from 20 to 1000 times. The radionuclides were at or below the instrument detection limit of 0.05 pCi/L in all eight experimental runs, which may indicate that even greater removal effectiveness was achieved. Results also suggest effective removal of these radionuclides in both their oxidized and reduced forms. Since positive results were achieved under the various test conditions, additional optimization testing will be needed to define the most favorable conditions for all analytical parameters. These tests are scheduled for completion during FY 93, and test results will be reported in the FY 93 Annual Report.

5.5 TREATABILITY STUDY WORK PLAN FOR OXIDATION/REDUCTION PROCESSES

A work plan to examine the treatment effectiveness of a variety of oxidation/reduction (redox) processes on representative groundwater and surface water samples at RFP was finalized in FY 92 (EG&G 1992i). This final Redox Work Plan has been submitted to DOE. Three phases of work, which are likely to require 29 weeks to complete, were identified in the work plan. Results from redox treatability work may be summarized in the FY 93 Annual Report, depending on the starting date for the proposed activities.

Redox treatment changes the oxidation state of a reactant of interest (e.g., plutonium), through addition of an oxidizing or reducing agent. This chemical change is followed by precipitation of the reactant in a more insoluble form (e.g., an insoluble metal salt). Redox processes are commonly applied to metal and radionuclide removal. Alum co-precipitation will be tested in order to evaluate the potential to increase precipitation effectiveness. Several metal and radionuclide species are encountered in surface water and groundwater at RFP. As a result, the use of a single oxidizing or reducing agent to treat all potential metals or radionuclides is not feasible. The Redox Work Plan was prepared to evaluate the most appropriate redox agent(s). Based on treatability data available to-date, oxidation has not proved effective for removing most target compounds.

Oxidation will be evaluated for iron and manganese removal only. A matrix which compares the potential usefulness of various redox agents or co-precipitation agents for treating the target compounds was prepared for the Redox Work Plan. Figure 5-7 shows this matrix. Data developed as part of the proposed work will be useful in evaluating the potential use of redox processes on a sitewide basis at RFP.

5.6 PLUTONIUM IN SOILS TREATABILITY TESTING

A treatability studies work plan was approved during FY 92 to conduct laboratory- and bench-scale tests with High-Gradient Magnetic Separation (HGMS) and the TRUclean® Process, respectively. The key objective of the tests is to evaluate each technology in terms of effectiveness at removing low levels of plutonium from contaminated surface soils originating at RFP. The title of the work plan is *Plutonium in Soils Treatability Studies Work Plans: TRUclean® Process and Magnetic Separation* (EG&G 1991b).

These tests will not likely be completed during FY 93. However, a description is given for the proposed tests with the TRUclean® Process and HGMS. Note that Magnetic Separation was first described in the Final TSP, and the technology was retained for treatability tests. The following specific description on HGMS updates the status of treatability studies regarding this technology.

5.6.1 High-Gradient Magnetic Separation

The HGMS treatability tests for the isolation of plutonium from plutonium-contaminated soils will provide a "laboratory" level of screening for this technology (EG&G 1991b). Operators at LANL will attempt to optimize the performance of an HGMS (Model PEM 1" Crossfield Separator, or equivalent) with surface soil from OU 2 at RFP.

Contaminant Type

Oxidation	Al	Sb	As	Ba	Be	Cd	Cr	Fe	Pb	Mn	Hg	Ni	Se	Pu	Ra	U
1. Air/Oxygen								●		○						
2. Hypochlorite								●								
3. Potassium Permanganate								●		●						

Reduction	Al	Sb	As	Ba	Be	Cd	Cr	Fe	Pb	Mn	Hg	Ni	Se	Pu	Ra	U
1. Stannous Chloride							○				●		○	●		○
2. Ferrous Salt							●						●	●		○
3. Sulfite							●						○	●		○
4. Acidic Iron													●	○		○

Precipitation	Al	Sb	As	Ba	Be	Cd	Cr	Fe	Pb	Mn	Hg	Ni	Se	Pu	Ra	U
1. Lime	●	○	●		○	●	●	●	●	●	○	●				
2. Alum		○	●		○									○		●
3. Ferric Salt		○	●		○	●	●		●			○	●	○		○
4. Phosphate	●						●	●	●					○		●
5. Barium Chloride/Sodium Sulfate				●											●	
6. Lime/sulfide						●			●		●	●				

- Target Constituent
○ Potentially Effective

Matrix of Relationships Between Metallic Contaminants and Treatment Process Reactions For Oxidation/Reduction Treatability Processes

HGMS is a specific process option for the general technology category of magnetic separation. Magnetic separation was selected for laboratory treatability testing during the development of the Final TSP. Magnetic separation segregates solid materials based on differences in magnetic susceptibility. Solids may be classified as diamagnetic or paramagnetic. Diamagnetic solids have a negative (-) magnetic susceptibility and repel a magnetic field. Paramagnetic solids have a positive (+) magnetic susceptibility and are attracted by a magnetic field. Paramagnetic solids are typically categorized into one of the following groups:

- Strongly magnetic (ferromagnetic)
- Weakly magnetic
- Nonmagnetic

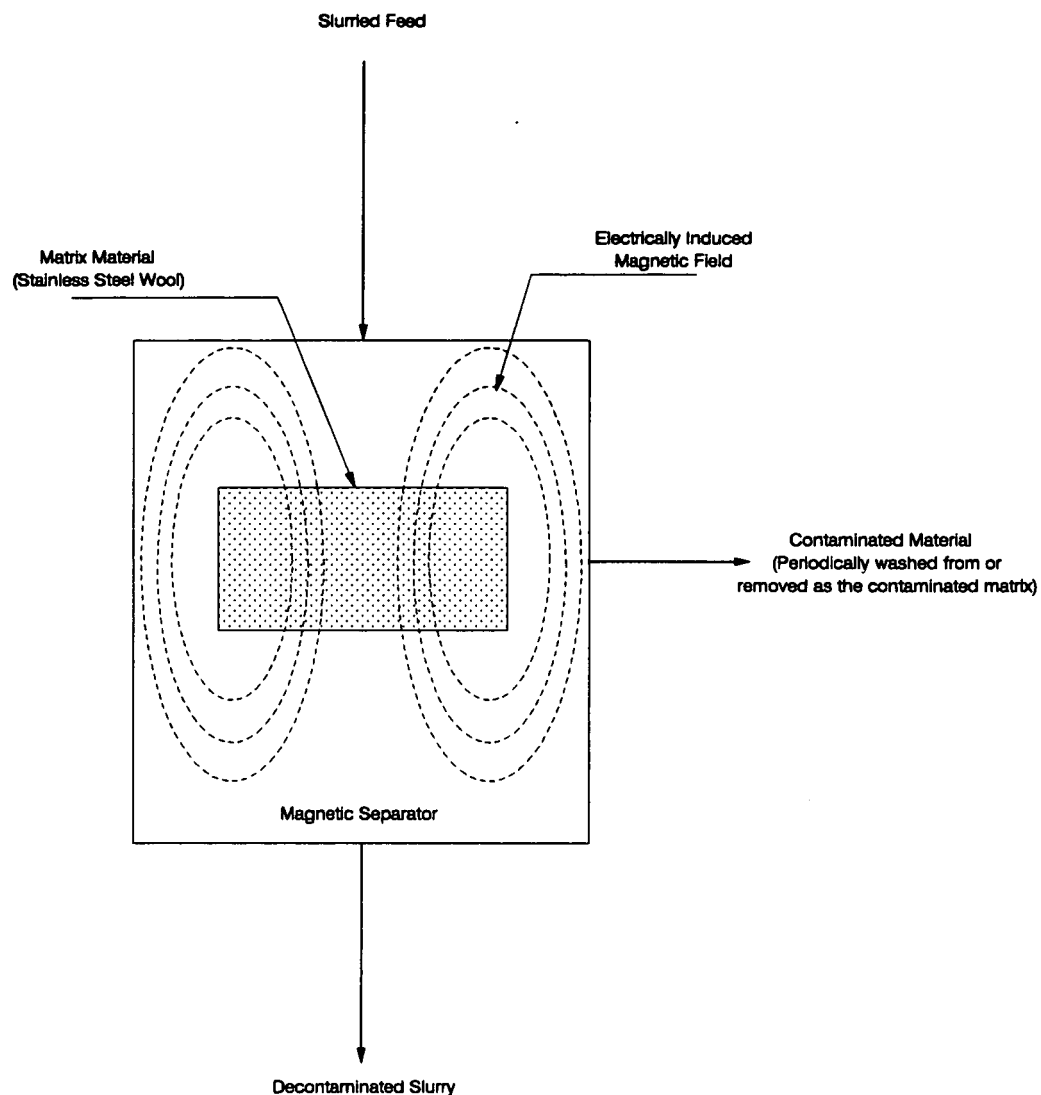
Plutonium and plutonium compounds, such as plutonium dioxide, exhibit paramagnetic properties and could be considered strongly magnetic (magnetic susceptibility of 730×10^{-6} centigauss units (Weast 1982) relative to other components of the RFP surface soil. Magnetic susceptibility is the basis for evaluating the potential effectiveness of magnetic separation. Figure 5-8 provides a simple flow diagram that represents a typical HGMS process.

The HGMS treatability test is designed to provide performance data that will enable the RFP to evaluate HGMS as a treatment technology for possible integration into environmental restoration efforts as an alternative for treatment of plutonium-contaminated soils. The HGMS treatability test at LANL will be structured as shown in Figure 5-9. The figure shows a progression that includes process optimization through surrogate tests, model runs, and final tests. Critical parameters of the HGMS to be optimized include the following:

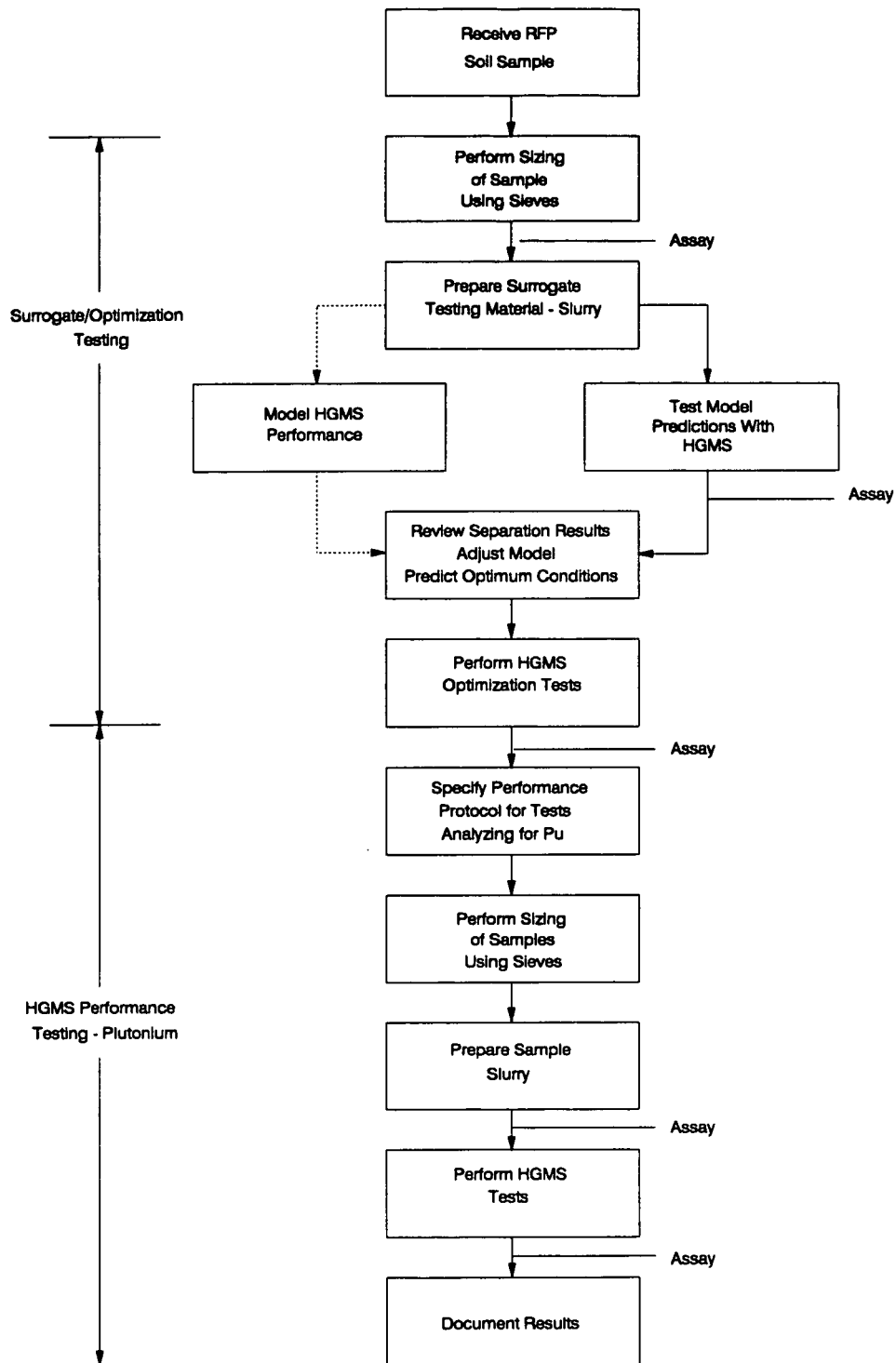
- Magnetic field strength
- Flowrate of slurried soil through the High-Gradient Magnetic Separator
- Solid/Liquid ratio
- Matrix type

A preliminary optimization of the above parameters will be accomplished through HGMS tests performed on RFP soil spiked with a surrogate contaminant such as copper oxide, nickel oxide, or palladium. The surrogate materials exhibit paramagnetic susceptibilities that are similar to those of plutonium dioxide, the dominant form of plutonium contamination found in RFP soil.

Once the critical parameters of HGMS have been optimized and ranked in terms of their impact on HGMS performance, a phased testing program will be implemented, with the focus being to use plutonium contaminated soil. The phased approach will involve testing the HGMS with three to five settings of each of the four critical parameters, one parameter at a time, beginning with the critical parameter determined to have the greatest impact on performance during the optimization



High Gradient Magnetic Separation General Flow Diagram



High Gradient Magnetic Separation Treatability Test Structure

procedure. The remaining critical parameters will be maintained at prescribed optimum levels. Of the three to five settings tested, the setting that produces an optimum performance becomes the new optimum level for that parameter. This type of adjustment to the optimum levels will be repeated for each parameter.

5.6.2 TRUclean® Process

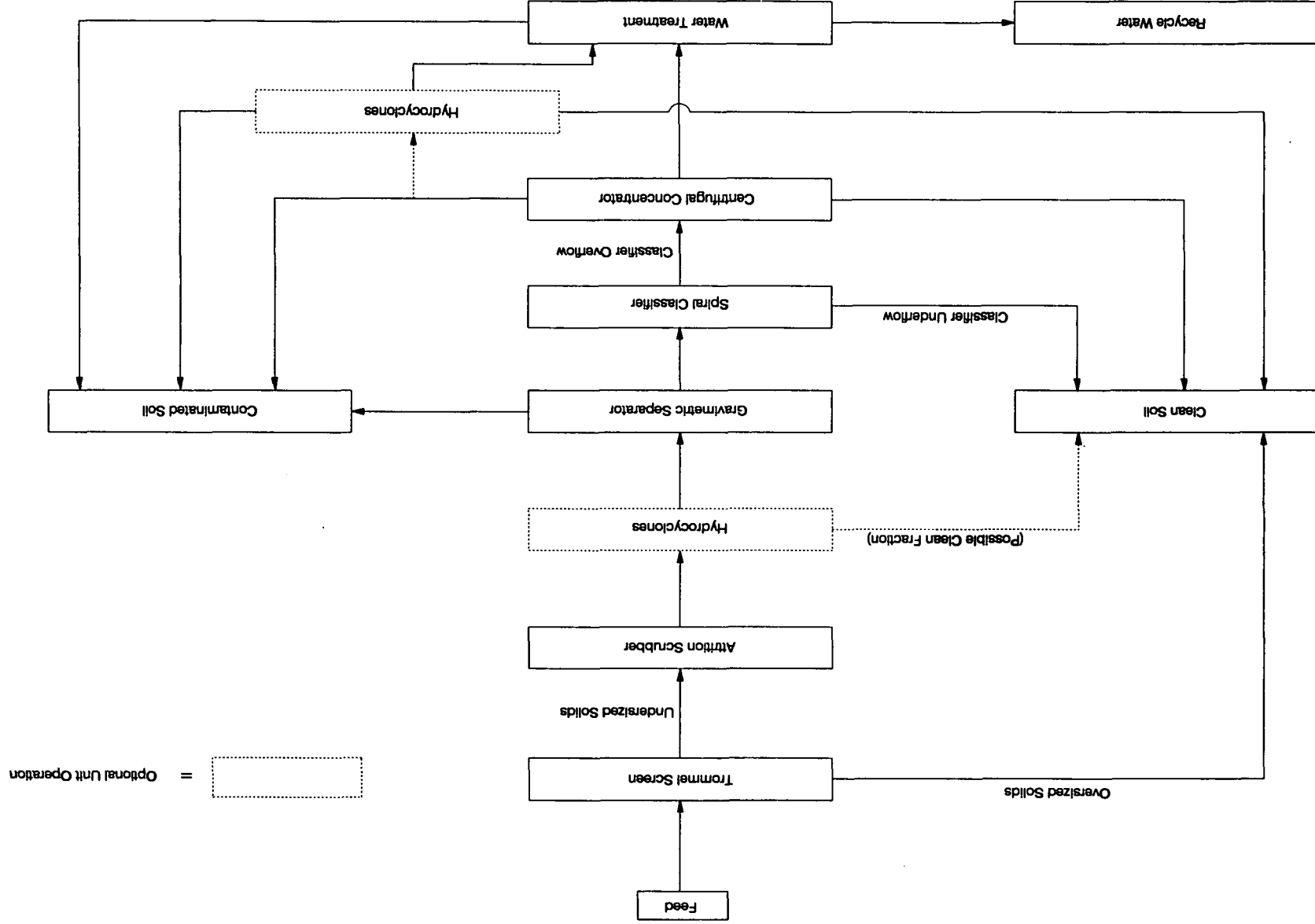
The TRUclean® Process treatability test for the isolation of plutonium from plutonium-contaminated soils is expected to begin in FY 93 (EG&G 1991b). TRUclean® was selected during the development of the TSP for bench-scale treatability testing. The following information on the TRUclean® Process is proprietary to AWC-Lockheed (hereinafter referred to as AWC).

The treatability tests will be conducted at the Nevada Test Site (NTS) with equipment operated by AWC. Operators at AWC will attempt to optimize the performance of the TRUclean® Process with untreated surface soils obtained from OU 2 at RFP. Figure 5-10 is a general representation of the unit operations that make up the TRUclean® Process. AWC will attempt to optimize the performance of the TRUclean® process with untreated RFP soil by varying process parameters of the individual unit operations. Parameters such as bed depth of the gravimetric separator (GS), solids/liquid ratio in the attrition scrubber, and pH of the wash solution will be varied as part of the optimization procedure.

The key component of the TRUclean® Process to be tested as part of this treatability study is a GS. A GS separates materials with differing specific gravities by passing a slurried material over a screen and screen bed subjected to a vertical hydraulic pulse. The pulse consists of a sudden upflow of water through the screen and screen bed with sufficient velocity to bring all particles momentarily into suspension (i.e., the screen bed becomes fluidized). At the completion of the pulse, the water drains back through the screen and screen bed and the pulse cycle is repeated. The pulsing cycle allows heavy particles to settle through the screen bed and lighter particles to pass over the top of the screen bed. Heavy particles that are small enough to pass through the screen are discharged continuously. Coarse, heavy particles not passing through the screen are withdrawn intermittently. Figure 5-11 provides a simple diagram for the components and streams of a typical GS.

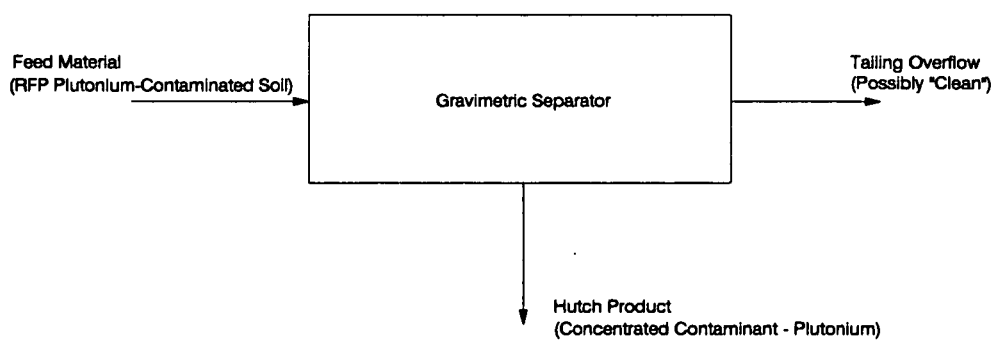
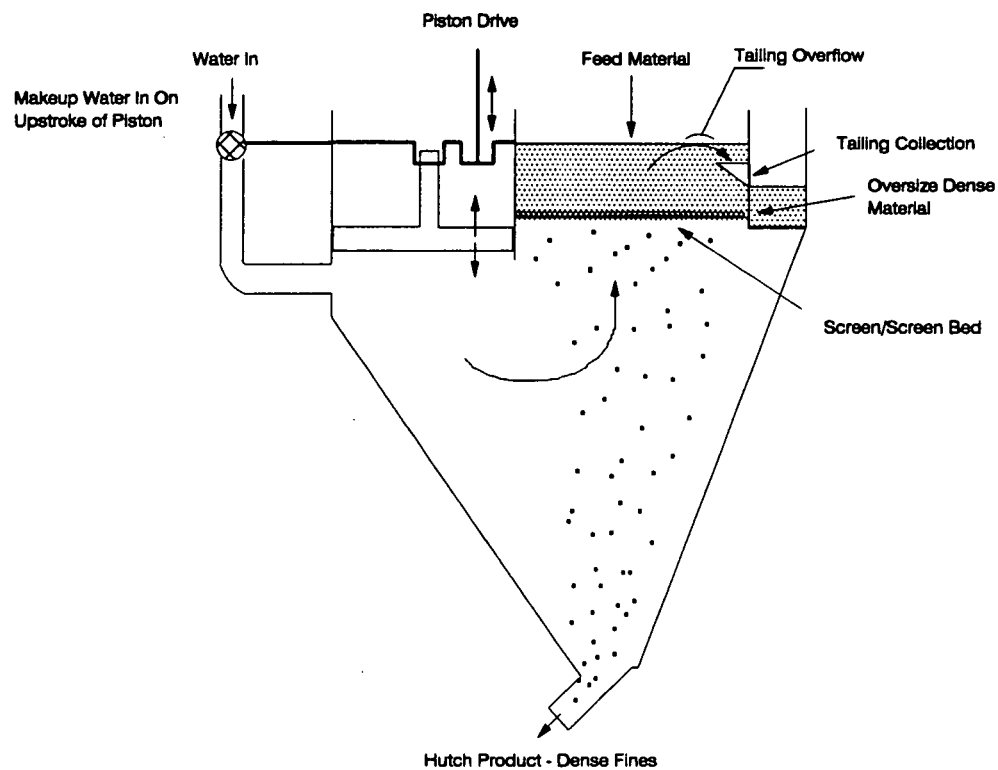
The ability of a GS to achieve fractionation by particle density and particle size is what may provide an isolation of plutonium contamination in RFP soil. Since plutonium (specifically plutonium dioxide) has a high specific gravity (Sp. Gr. = 11.5) and is associated with fines (EG&G 1991b), it is expected that the plutonium contamination will be concentrated primarily in the dense fines which pass through the screen.

TRUclean Process General Flow Diagram



= Optional Unit Operation

Figure 5-10



TRUclean Process General Configuration and Flow

To enhance the performance of the TRUclean® Process GS, several feed preparation steps will be incorporated into the treatability tests. These steps involve use of the other unit operations noted in Figure 5-10 and include wet screening of the contaminated soil by a trommel screen, attrition scrubbing to promote separation of plutonium particulates from the soil aggregate, and particle size fractionation by hydrocyclones.

Given the complexity of the overall TRUclean® Process, a key goal of the treatability tests will be to select the best process equipment and place that equipment in the most effective sequence to effect separation of clean (less than 0.9 pico curies per gram (pCi/g) plutonium) soils from plutonium contamination.

The experimental design for the TRUclean® Process is based upon two phases of testing. Phase I will consist of testing individual pieces of process equipment—each representing different unit operations in order to determine elements such as: capacity to isolate plutonium-contaminated soils, optimum size fraction(s) cleaned, optimum settings for physical variables, optimum settings for process variables. Once the Phase I optimization data are evaluated and the optimum design developed, the RFP will approve the design and the Phase II portion of testing will begin. As part of Phase II, the process equipment units will be placed, based upon the Phase I evaluation, in the most effective sequence to separate clean soils from plutonium-contaminated soils. The experimental design for Phase II will consist of three runs. Each of these runs will test 90 to 91 kilograms of contaminated soil.

5.7 COLLOIDAL/SOLUTION - PHASE TRANSPORT OF RADIONUCLIDES

A joint study has been initiated between DOE and the U. S. Geological Survey (USGS) to evaluate colloidal-and solution-phase transport of americium and plutonium in groundwater at RFP (USGS 1992). Research objectives of the project are: (1) to determine chemical and mineralogical characteristics of colloidal material in surface water and groundwater for evaluating sorption affinity of the radionuclides to colloids; (2) determine phase distribution of the radionuclides between colloidal and solution phases; (3) to determine distribution variations of the radionuclides along a groundwater flow path; and, (4) to interpret phase distribution results related to radionuclide transport for purposes of evaluating remediation issues.

The project was divided into two phases. Phase I was completed in April 1992 and involved preliminary groundwater sampling, colloidal filtration for radiochemical and scanning electron microscope analysis, and preparation of an initial report. Five conclusions were reached during phase I research :

- Particulate and colloidal material in water facilitate the transport of plutonium in the groundwater; up to 65% of the plutonium 238-240 activity in the groundwater was associated with the colloidal (22%) and particulate (43%) fractions. The dissolved fraction contained the remaining 35% of plutonium activity. Isotopes of americium and uranium concentrations were too low for analysis.
- Mineral species such as iron oxyhydroxide (greater than 5 microns) and clay minerals (from 0.1 to 5 microns) in the particulate fraction may potentiate the transport of radionuclides by sorption, increasing mobility. Organic species may contribute to the transport of actinides in the colloidal fraction.
- Relatively high concentrations of zinc and copper found in the smallest colloidal fraction suggest organic complexation of the metals by humic and fulvic acids. The role of organics as complexation agents for actinides both in the particulate/colloid and the dissolved fraction will be studied further in phase II.
- Colloid concentrations are much less than 1 mg/L in the groundwater, which poses challenges to the isolation and characterization of the colloidal phase. Phase II sampling will require filtration of larger volumes and require longer storage times.
- Enhanced transport is possible during periodic leaching events. Future sampling will need to coincide with rain or snow melt to evaluate the effect of episodic leaching events.

Phase II will be completed in May 1993. It will involve more extensive sampling and analyses using Phase I results, develop more effective procedures for phase determinations of colloids and associated americium and plutonium, and finally prepare a detailed interpretive report of results and the application of data collected to assist in remediation efforts at RFP.

5.8 COMPREHENSIVE TREATMENT AND MANAGEMENT PLAN

The Comprehensive Treatment and Management Plan (CTMP) was developed by DOE in order to comply with Land Disposal Restrictions (LDRs) noted in 40 CFR 268. This RCRA restriction requires that a generator of a hazardous (and/or) mixed waste must treat the waste to meet specific concentration based treatment standards or must treat the waste utilizing specific treatment technologies prior to disposal of the waste. The LDRs also prohibit long term storage of hazardous or mixed waste that do not meet the treatment standards unless such storage is specifically "...for the purpose of accumulation of such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal..." (40 CFR 268.50). Because of acknowledged

lack of mixed waste capacity on a RFP specific and also on a national basis, accumulation of mixed waste at RFP may be considered to be inconsistent with storage prohibition of 40 CFR 268.50. As a result, DOE and EPA have entered into a Federal Facility Compliance Agreement which provides time for RFP to systematically address and achieve total compliance with the LDR regulations. The agreement does not place RFP into compliance, however, a mechanism for DOE to take a variety of steps toward resolution of the LDR issues. At the current time, all compliance requirements specified in the agreement have been met on, or ahead of schedule. The primary mechanism for achieving compliance is outlined in the CTMP, in which RFP has outlined the approach, schedules, and milestones for developing and implementing treatment systems for treating mixed wastes to satisfy the treatment standards specified in the LDR regulations. Specific milestones scheduled in the CTMP include: (1) submitting treatability study exemptions; (2) submitting research and development (R&D) permit applications; (3) submitting Part B permit application modifications; (4) initiating SO testing on the production facility or system; and, (5) submitting a waste processing schedule. The wastes subject to LDRs as described in the CTMP include: (1) low-level mixed (LLM) solvent contaminated wastes; (2) LLM solidified sludges; (3) miscellaneous LLM waste forms; (4) Building 374/774 LLM wastes; and, (5) LLM surface organics removal, leaded gloves, and bulk lead treatment system wastes. The proposed schedule for achieving the various CTMP milestones extends from FY 92 through FY 2007.

5.9 SECONDARY RESIDUES FROM TREATABILITY STUDIES

Treatability study processes will produce secondary residues as a by-product of treatment. The requirements for handling the residues and wastes will vary with regard to the contaminants involved as well as the treatment methods employed in the treatability study. Therefore, the residues produced by each treatability study must be considered separately.

In general, it is expected that the secondary residues from water treatment processes will be minimal. The residues will consist of treatment materials, ion exchange resins, adsorption materials, or treatment sludges, and contaminated equipment (gloves, miscellaneous lab equipment, etc.). The treated water itself will be disposed of at the treatment site, in accordance with the permits held by the treatment facility. Untreated water, depending on the volume remaining, the contaminant involved, and the contaminant level, will either be disposed of at the treatment site (i.e. offsite treatability study laboratory) or returned to Rocky Flats for treatment and/or disposal.

The secondary residues from the soil treatability studies are expected to fall into one or more of the following categories: 1) a clean soil fraction which does not require any further treatment and could be used as back fill in the area where the soil was obtained, 2) a concentrated plutonium fraction; 3) a fraction containing concentrated heavy metals; 4) a fraction containing organic

materials; and 5) miscellaneous (gloves; lab equipment, etc.). All secondary residues will be maintained as separate products.

Once the treatability study has been completed, it is expected that all of the secondary soil residues will be returned to Rocky Flats along with any untreated soils for proper treatment and disposal. The miscellaneous fraction may or may not be returned to the Rocky Flats Plant depending on the treatability study vendor's procedure for handling these waste materials. Any concentrated plutonium fraction will need extra consideration and attention to determine if the elevated plutonium levels will require more stringent handling and DOT shipping standards or accountability of Special Nuclear Material (SNM) by Rocky Flats.

The issue of secondary treatment is being considered for each treatability study. For most studies the quantities involved are on the order of 50 to a few hundred pounds and most likely will not fill more than one or two 55 gallon drums.

6.1 PROJECT SELECTION

After a technology has been screened using technological criteria, administrative screening must take place before a study is approved and funded. Administrative factors for project selection included:

- Cost of project;
- Anticipated degree of clean-up success;
- Applicability to Rocky Flats environmental remediation efforts; and
- Internal scheduling.

Using these criteria and funding priorities as listed below, projects were selected and deliverables determined as shown in Table 6-1. Opportunities for other joint participation projects are anticipated to arise throughout the year. Each project will be considered and selected or rejected based on the factors listed above. Since many of the projects of this type are small scale, short duration projects, formal work plans will not generally be developed. When a project is selected, DOE will notify the agencies and submit a work plan outline for agency review and comment. DOE will incorporate the comments in the final work plan outline with the agreement of the other participants in the joint treatability study.

6.2 PRIORITIZATION OF PROJECTS AND SCHEDULING OF PROJECT WORK

During the planning phase for the Fiscal Year 1993, the Sitewide Treatability projects were given priority in the following manner:

- Laboratory scale projects were given priority over field demonstrations which were put on hold until FY 94.
- IAG Milestone deliverables were funded first.
- Projects that were underway and close to completion were funded next.
- Projects that could be funded and completed in FY 93 were then funded.
- Projects that could be separated into phases that could be completed during the fiscal year were funded next.
- Joint participation projects were evaluated, and two projects were under consideration as the fiscal year began, bioremediation of plutonium soils at LANL, and a plasma melter with AWC (Lockheed).

The schedule of projects as selected appears in Table 6-1; tentative projects have yet to be scheduled and are not shown (i.e. Solar Detoxification and Plasma Melter). Note that the submittal dates for the Fiscal Year Reports are IAG milestones; dates for other reports are only tentative.

- EG&G 1990, *Background Geochemical Characterization Report*, Rocky Flats Plant, for 1989, Golden, Colorado
- EG&G 1991a, *Final Treatability Studies Plan*, Rocky Flats Plant, Golden, Colorado
- EG&G 1991b, *Plutonium in Soils Treatability Studies Work Plans: TRUclean® Process and Magnetic Separation*.
- EG&G 1992a, *Annual Report for Treatability Studies at Rocky Flats Plant*, Fiscal Year 1991, Golden, Colorado.
- EG&G 1992b, *Final Work Plan for the Control of Radionuclide Levels in Water Discharges From the Rocky Flats Plant*, Golden, Colorado.
- EG&G 1992c, personal communication with Mark Burmeister, OU 1 Interim Remedial Action Site Manager.
- EG&G 1992d, *Preliminary Draft System Operation and Optimization Test Report, Interim Measure/Interim Remedial Action for the 881 Hillside Operable Unit 1*, Rocky Flats Plant, Golden, Colorado.
- EG&G 1992e, *Operable Unit 1, (IHSSs 119.1 and 119.2) - Treatability Study Work Plan, Soil Flushing, Biotreatment, and Radio Frequency Heating*, September
- EG&G 1992f, *Summary and Analysis of Results, Field Treatability Study, Granular Activated Carbon Treatment System, Phase I, Surface Water IM/IRA, Operable Unit No. 2*, Rocky Flats Plant, Golden, Colorado
- EG&G 1992g, personal communication with Dennis Pontius, OU 2 Surface Water Interim Remedial Action Site Manager.
- EG&G 1992h, *Proposed Subsurface Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document, Operable Unit 2*, Rocky Flats Plant, Golden, Colorado.

EG&G 1992i, *Final Treatability Study Work Plan for Oxidation/Reduction Processes, Environmental Restoration Program*, Rocky Flats Plant, Golden, Colorado.

Laul, J. C., O. Erlich, C. Trice, and T. C. Greengard, 1992, *Removal of Uranium, Plutonium, and Americium From Rocky Flats Waste Water*, in *Proceedings of Nuclear and Hazardous Waste Management*, Spectrum 92 International Topical Meeting, Boise, Idaho, pp. 637-642.

U. S. EPA, 1989, *Interim Final RCRA Facility Investigation (RFI) Guidance, Volume I of IV*, May. OSWER No. 9502.00-6D.

U. S. EPA 1991a, *Innovative Treatment Technologies, Overview and Guide to Information Sources*, EPA/540/9-91/002, October.

U. S. EPA 1991b, *The Superfund Innovative Technology Evaluation Program: Technology Profiles*, Fourth Edition, EPA/540/5-81/008, November.

U. S. EPA 1991c, *Remedial Action, Treatment, and Disposal of Hazardous Waste, Proceedings of the Seventeenth Annual RREL Hazardous Waste Research Symposium*, April.

USGS, 1992, *Summary of USGS Colloidal Transport Project Field Activities at OU 2 from May 12 Through May 31, 1992*. Unpublished report.

Weast, R. C., et al, 1982, *CRC Handbook of Chemistry and Physics*, 63rd edition.

TABLE 2-1
SUMMARY OF NEW MAXIMUM ANALYTE CONCENTRATIONS, FY 92 ANALYTICAL DATA

Analyte	Previous Maximum Value (FY 91)	New Maximum Value (FY 92)	Medium	Operable Unit
Aluminum	37.7 mg/L	53.1 mg/L	Groundwater	1
Calcium	99.9 mg/L	316 mg/L	Groundwater	1
Iron	76.6 mg/L	248 mg/L	Groundwater	2
1,1-Dichloroethane	344 µg/L	500 µg/L	Groundwater	1
beta-BHC	— ⁽¹⁾	0.055 µg/L	Groundwater	1
Diethyl Phthalate	—	4 µg/L	Groundwater	1
Benzoic Acid	—	14 µg/L	Groundwater	1
Barium	1,899 mg/kg	11,600 mg/kg	Soil	8
Iron	75,900 mg/kg	123,000 mg/kg	Soil	8
Potassium	8,020 mg/kg	8,990 mg/kg	Soil	2
1,2,2-Tetrachloroethane	—	3 µg/kg	Soil	2
2-Butanone	530 µg/kg	1,000 µg/kg	Soil	1
4-Methyl-2-Pentanone	120 µg/kg	2,000 µg/kg	Soil	1
Acetone	2,400 µg/kg	39,000 µg/kg	Soil	1
Chloroform	130 µg/kg	1,000 µg/kg	Soil	8
Methylene Chloride	590 µg/kg	9,000 µg/kg	Soil	1
Styrene	17 µg/kg	6,000 µg/kg	Soil	8
Toluene	860 µg/kg	1,000 µg/kg	Soil	8
1,3-Dichlorobenzene	—	180 µg/kg	Soil	1
1,4-Dichlorobenzene	—	110 µg/kg	Soil	1
Acenaphthene	57 µg/kg	230 µg/kg	Soil	2

(1) Values reported in this table have been summarized from Tables B-1 through B-5 in Appendix B. Values shown do not necessarily represent validated data.

TABLE 2-1. (continued)

Analyte	Previous Maximum Value (FY 91)	New Maximum Value (FY 92)	Medium	Operable Unit
Benzo(a)pyrene	230 µg/kg	350 µg/kg	Soil	2
Benzoic Acid	400 µg/kg	2,000 µg/kg	Soil	1
Diethyl Phthalate	31 µg/kg	82 µg/kg	Soil	2
2-Methylnaphthalene	—	160 µg/kg	Soil	2
Silicon	—	16.4 mg/kg	Soil	2
Sulfide	200 µg/kg	5,000 µg/kg	Soil	8
Oil & Grease	1,100 mg/kg	6,800 mg/kg	Sediment	1
Bis (2-ethylexyl) Phthalate	41 µg/kg	1,300 µg/kg	Sediment	1
Manganese	27.7 mg/L	32.1 mg/L	Surface Water	8

(1) Values reported in this table have been summarized from Tables B-1 through B-5 in Appendix B. Values shown do not necessarily represent validated data.

(2) Indicates no occurrence of the given analyte was noted during previous characterization activities.

TABLE 2-2

**MAXIMUM AND MINIMUM ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum*	Minimum**	Preliminary TSBs	Maximum*	Minimum**	Preliminary TSBs	Maximum*	Minimum**	Background Concentration**	Maximum*	Minimum**	Background Concentration***
METALS (TOTAL AND DISSOLVED)	(mg/L)			(mg/L)			(mg/kg)			(mg/kg)		
Aluminum	53.1	0.200	0.2	293	0.200	0.200	70600	40	102000	33900	40	21600
Antimony	0.628	0.060	0.006	0.643	0.060	0.060	57	12	47	69.7	12	42.1 + +
Arsenic	3.0	0.010	0.05	1.03	0.010	0.05	64	2.0	41.8	49.2	2	13
Barium	0.943	0.200	2.0	11600	0.200	1.0	11600	40	777	706	40	182
Beryllium	0.04	0.005	.004	0.170	0.005	0.005	18.3	1.0	23.5	15.5	1.0	3.5 + +
Boron	0.218	5.0	5.0									
Cadmium	0.0352 BR	0.005	0.005	25	0.005	0.005	119	1.0	1.5	19.5	1.0	3.3 + +
Calcium	316 BR	5.000		1590	5.000		254000	2000	157000	132000	2000	52500
Cesium	0.4	1.000		12	1.000		2410	200	274	700	*	702 + +
Chromium	0.172 BR	0.010	0.05	0.298	0.010	0.05	781	2.0	176	64	2.0	30.4
Cobalt	0.22	0.050	0.05	0.489	0.050		88.9	10	93.9	43.3	*	10
Copper	3.13	0.025	0.2	0.908	0.025	0.025	73.6	5.0	123	275	5.0	22
Iron	248	0.100	0.3	3220	0.100	0.30	123000	20	132000	33300	20	15000
Lead	2.8	0.005	0.05	0.950	0.005	0.005	86.9	1.0	44	255	1.0	49.1
Lithium	1.79	0.100	2.5	85.2	0.100		100	20	83.2	958	20	70.2 + +
Magnesium	788	5.000		391	5.000		23300	2000	32500	103000	2000	4110
Manganese	11.34	0.015	0.05	32.1	0.015	0.050	3540	3.0	3330	1950	3.0	352
Mercury	0.013	0.0002	0.002	3.97	0.0002	0.0002	114	0.2	0.64	1.5	0.2	0.35 + +
Molybdenum	1.92 BR	0.200		0.680	0.200		38.65	40	67.6	177	40	70.2 + +
Nickel	11.7	0.040	0.1	0.82	0.040	0.4	543	8.0	193	89.2	*	8.0
Phosphorus	1.210	0.040		12	0.040					655	200	

* = Present in laboratory blank

** = Background concentrations taken from Draft Final Phase III RFP/RI Report, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1

*** = Background concentrations taken from Final Background Geochemical Characterization Report, Rocky Flats Plant, December, 1990.

J = Analyzed below detection limit

BR = Bedrock (including some weathered bedrock)

+ = Maximum concentration may be a one-time measurement. Values compiled from both recent and historic data, checked against Rocky Flats Environmental Data System.

+ + = Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (G.R.R.A.S.P.), v.1.1, 1990, EG&G Rocky Flats Environmental Restoration Program.

(a) = Plutonium 238 + 239 + 240

(b) = Radium 226 + 228

(c) = Ammonia as N

(d) = Sum of polychlorinated biphenyls (PCBs) in water

(e) = Based on Colorado Radiation Control Rules and Regulations, December 1985.

(f) = Site specific standards

TABLE 2-2

**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
METALS (TOTAL AND DISSOLVED) (Continued)	(mg/L)			(mg/L)			(mg/kg)			(mg/kg)		
Potassium	7050	5.000		4260	5.000		8990	2000	18700	67000	2000	3510 + +
Selenium	100.3	0.005	0.010	0.55	0.005	0.005	6.5	1.0	1.1	21.3	1.0	2.5 + +
Silicon	56.4	0.010		44	0.010		16.4	4.7		2470	4.8	
Silver	0.217	0.010	0.050	0.148	0.010	0.010	40.9	2.0	40.9	411	2.0	6.8
Sodium	4447	5.000		9080	5.000		44000	2000	3680	1480	2000	3510 + +
Strontium	82.4	0.200		11.9	0.200		1030	40	226	1230	40	397 + +
Thallium	0.544	0.050	0.01	0.029	0.050	0.050	5.74	2.0	0.41	90	2.0	4.2 + +
Tin	1.121	0.200		1.53	0.200		382	40	441	1080	40	70.2 + +
Vanadium	0.85	0.050	0.1	1.85	0.050		2590	10	283	90.4	10	50.2
Zinc	5.0	0.020	2.0	28.7	0.020	0.110	487	4.0	486	735	4.0	79.8
ANIONS	(mg/L)			(mg/L)			(mg/kg)			(mg/kg)		
Ammonia				65	0.5	0.5						
Alkalinity as CaCO ₃	3151	10		341	10					8590		
Bicarbonate as CaCO ₃	2640	10		4100	10					3500		
Carbonate as CaCO ₃	510	10		270	10				0	130		
Chloride	1100	5.0	250	1200	5.0	230	20			210		
Cyanide	3.8	0.01	0.2	0.6	0.01	0.01	19.8			1.0		

* = Present in laboratory blank

** = Background concentrations taken from Draft Final Phase III RFP/RI Report, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1

*** = Background concentrations taken from Final Background Geochemical Characterization Report, Rocky Flats Plant, December, 1990.

J = Analyzed below detection limit

BR = Bedrock (including some weathered bedrock)

+ = Maximum concentration may be a one-time measurement. Values compiled from both recent and historic data, checked against Rocky Flats Environmental Data System.

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(a) = Plutonium 238 + 239 + 240

(b) = Radium 226 + 228

(c) = Ammonia as N

(d) = Sum of polychlorinated biphenyls (PCBs) in water

(e) = Based on Colorado Radiation Control Rules and Regulations, December 1985.

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TABLE 2-2

**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
ANIONS (Continued)	(mg/L)			(mg/L)			(mg/kg)			(mg/kg)		
Fluoride	8.2	5.0	5.0	7.7	5.0	5.0						
Nitrate as N	1450	5.0	10.0	1186	5.0	10.0	4.3			35.86		
Nitrate + Nitrite as N	12100	5.0	10.0	7800	5.0	10.0	3400		4.79	163		
Nitrite as N	1.98	5.0	5.0	.430	5.0	5.0				3.1	0.2	
Orthophosphate	0.92	0.01		7.9	0.01							
Phosphate	15	0.1		2.1	0.1							
Sulfate	19000	5.0	250	1900	5.0	250	400			744		
Sulfide	13	2.0		120	2.0	2.0	5000	4.0	7.2	23		
Total Kjeldahl Nitrogen				61	1							
Total Organic Carbon				30.9	2		56000					
INDICATORS	(mg/L)			(mg/L)			(mg/kg)			(mg/kg)		
Biochemical O ₂ Demand				260	2.0							
Conductivity Min. (umho/cm)				73.7	1.0							
Conductivity Max. (umho/cm)				37120	1.0							
Dissolved Oxygen (mg/L)												

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(a) = Plutonium 238 + 239 + 240

(b) = Radium 226 + 228

(c) = Ammonia as N

(d) = Sum of polychlorinated biphenyls (PCBs) in water

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TABLE 2-2

**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
INDICATORS (continued)	(mg/L)			(mg/L)			(mg/kg)			(mg/kg)		
Minimum				0.0	0.5	3.0						
Maximum				70	0.5							
Oil and Grease	32			439	5.0		567		0.17	6800		
Percent Solids (%)												
Minimum							78.9			14.7		
Maximum							96.4			98.95		
pH minimum (pH units)	5.98	0.1	6.5	3.4	0.1	6.5	5.65			6.1		
pH maximum (pH units)	12	0.1	8.5	10.2	0.1	8.5	11.1			9.6		
Temperature (degrees C)												
Minimum				2.0								
Maximum				33								
Total Dissolved Solids (mg/L)	37000	10	400	47000	10	250						
Total Suspended Solids (mg/L)	20000	5.0		46000	5.0							
RADIONUCLIDES (TOTAL AND DISSOLVED)	(pCi/L)			(pCi/L)			(pCi/g)			(pCi/g)		
Americium 241	9.68	0.01		90	0.01	30(f)	22	0.02	0.04046	1.467	0.02	0.02
Cesium 137	7.72	1.0		12	1.0		4.7	0.1		3.2	0.1	3.2
Gross Alpha	2000	2.0	7.0	2107	2.0	7.0	480	4.0	48	77	4.0	5.0 ^(e)

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TABLE 2-2

**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
RADIONUCLIDES (TOTAL AND DISSOLVED) (continued)	(pCi/L)			(pCi/L)			(pCi/g)			(pCi/g)		
Gross Beta	1200	4.0	5.0	3800	4.0	5.0	49.9	10	44	53	10	50 ^(a)
Plutonium 238	0.040	0.01	0.05	0.031	0.01					0.016	0.03	
Plutonium 239 + 240	8.13	0.01	15(a,f)	120	0.01	15(a,f)	180	0.03		3.3	0.03	0.9 ^(a)
Radium 226	3.54	0.5	5(b)	30	0.5	5(b)	1.9	0.5		1.96	0.5	1.1
Radium 228	13.95	1.0	5(b)	52	0.5	5(b)	2.8	0.5		4.41	0.5	2.3
Strontium 89 + 90	7.52	1.0		4.27	1.0		1.9	1	1.2	2.53	1	
Strontium 90	12.4	1.0	8.0	33.34	1.0	8.0	4.57	1		0.99	1	0.99
Tritium	12000	400	500(f)	13000	400	500(f)	3.9	400	440000	580	400	0.97
Uranium 233 + 234	1000	0.6		1050	0.6		3.7	0.3	8.9	4.11	0.3	1.48
Uranium 233 + 238 + 239	16.9	0.6		14.31	0.6					3.32	0.3	
Uranium 235	47	0.6		65.5	0.6		1.01	0.3	0.3	1.34	0.3	1.34
Uranium 235 + 238	6.90	0.6		47.5	0.6					0.15		
Uranium 238	750	0.6		1211	0.6		3.9	0.3	3.2	3.82	0.3	1.3
Uranium (Total)	63.7	0.6	5	1023	0.6	5.0	4.0 BR	0.3		4.8	0.3	

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TABLE 2-2

**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
VOLATILES	(ug/L)			(ug/L)			(ug/kg)			(ug/kg)		
1,1-Dichloroethane	500	5.0		50	5.0		49	5				
1,1-Dichloroethene	48000	5.0	7	143	5.0	7.0	110	5		5.0	J	5.0
1,1,1-Trichloroethane	30250	5.0	200	42	5.0	200	290	5.0		3.0	J	5.0
1,1,2-Trichloroethane	14740	5.0	5.0	6.0	5.0	5.0	62	5.0				
1,1,2,2-Tetrachloroethane	15	5.0	5	440	5.0	5.0						
1,2-Dichloroethane	16000	5.0	5	23			120	5.0				
1,2-Dichloroethene (Total)	14000	5.0		460	5.0	100	140	5.0				
1,2-Dichloropropane	6	5.0	5	7.0	5.0	5.0	3.0	5.0				
1,3-Dichloropropene	3	J	5.0	7.0	5.0	10	6.0	J	5.0			
2-Butanone	580	10		76	10		1000	10.0		12000		10
2-Chloroethylvinylether				5.0			31	J	10.0			
2-Hexanone	975	10		87			41					
4-Methyl-2-Pentanone	35	10.0		32	10		2000	J	10	220	5	10
Acetone	4100	J*	10.0	970	10	4000	39000	5	10	7300		10
Benzene	83	J	5.0	83	5	5	12	J	10	3.0	J	10

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TABLE 2-2

**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater				Surface Water				Soils				Sediments			
	Maximum*	Minimum**	Preliminary TSBs		Maximum*	Minimum**	Preliminary TSBs		Maximum*	Minimum**	Background Concentration**		Maximum*	Minimum**	Background Concentration***	
VOLATILES (continued)	(ug/L)				(ug/L)				(ug/kg)				(ug/kg)			
Bromodichloromethane	5.0	J	1.0	5.0	6.0	5	700									
Bromoform	5.0	J	1.0	5.0	3.0	5	700									
Bromomethane	7.0	J	10.0	10	8.0	10	48		6.0	J	10					
Carbon Disulfide	28		5.0	4000	29	5.0	4000		150				13	J	5.0	
Carbon Tetrachloride	28000		5.0	5.0	1005	5.0	5.0		180	*	5.0					
Chlorobenzene	73		5.0		94	5.0	100		150		55		4.0	J	5.0	
Chloroethane	17		10.0		34	10			50	J	10					
Chloroform	5427		5.0	5.0	84	5.0	5.0		1000	J	5.0		18		5.0	
Chloromethane	17		10.0		38	10							60		10	
Dibromochloromethane					5.0	5.0	6.0									
Ethylbenzene	16		5.0	680	18	5.0	680		780		5.0		4.0		5.0	
Methylene Chloride	4100		5.0	5.0	340	5.0	5.0		9000	BR	5.0		16000		5.0	
Styrene	9		5.0	100	6.0	5.0	100		6000	J	5.0		2.0	J	5.0	

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**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
SEMIVOLATILES (TOTAL)	(ug/L)			(ug/L)			(ug/kg)			(ug/kg)		
Tetrachloroethene	528000	5.0	5.0	280	5.0	5.0	10000	5.0		8.0	5.0	
Toluene	270	J	5.0 1000	94	5.0	1000	1000	5.0		120	5.0	
Trichloroethene	221860	5.0	5.0	2500	5.0	5.0	17000	5.0		39	5.0	
Vinyl Acetate	39	J	10	3.0	10							
Vinyl Chloride	930		10 10	25	10	10				57	J	10
Xylenes (Total)	50	J	5.0 10000	40	5.0	10000	3300	5.0		7.0	J	5.0
Acenaphthene				5.0	10	520	230	J	330 480	2400	J	330
Acenaphthylene									480	450	J	330
Aldrin				0.06	0.05	0.05						
Alpha-BHC				0.01	0.05	0.05				4.7	J	8.0
Alpha-chlordane				2.6	0.5	0.5						
Ametryn				0.18	0.06							
Anthracene				2.0	10	10	180	J	330 480	2900	J	330
Atrazine				2720.0	0.05	3.0						
Benzo(a)Anthracene				2.0	10	10	120	J	330 480	7100		330
Benzo(b)Fluoranthene				3.0	10	10	350	J	330 480	7100		330
Benzo(k)Fluoranthene				4.0	10	10	320	J	330 480	6300		330

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AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
SEMI-VOLATILES (TOTAL) (Continued)	(ug/L)			(ug/L)			(ug/kg)			(ug/kg)		
Benzo(g,h,i)Perylene							50	J	330	480	5700	330
Benzo(a)Pyrene			0.01	3.0	10.0	10	350	J		480	6300	330
Benzo(k)Pyrene							130	J	330			
Benzoic Acid	14.0	14.0		8.0	50		2000	J	1600	1800	3300	J 1600
Benzyl Alcohol				43	10							
Beta-BHC	0.055	0.055		0.1	0.05	0.05				11	13000	8.0
Bis (2-ethylhexyl) Phthalate	100	BR	10	220	10	10	18000	*	330	140	1300	330
Butyl Benzyl Phthalate	2.0	J	10	3.0	10	3000	510	J	330	480	540	J 330
4-Chloro-3-methylphenol				1.0	10	30	740		330	380		
4-Chlorophenyl Phenyl Ether							40	J	330			
Chrysene	420	10		2.0	10	10	550	J	330	480	8200	330
Cyanazine				0.3	0.1							
4,4-DDT				0.08	0.1	0.1					95	16
Delta-BHC				0.02	0.05						3.2	J 8.0
Dibenzo (a,h) Anthracene											1200	330
Dibenzofuran				1.0							1000	J
Dicamba				2.1	0.27							
1,4-Dichlorobenzene				4.0	10	75	110		43	480		

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AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
SEMI-VOLATILES (TOTAL) (continued)	(ug/L)			(ug/L)			(ug/kg)			(ug/kg)		
1,3-Dichlorobenzene							180	180				
Dichloroprop				1.8	0.65							
Diethyl Phthalate	4	2		6.0	10	23000	82	330	480	1200	330	
Di-n-Butyl Phthalate	170	J BR	10	20	10	10	3643	J	330	44	3100	330
Di-n-Octyl Phthalate	56	J BR	10	24	10		370	J	330	480	2000	330
2,4-Dimethylphenol				6.0	10	2120						
2,4-Dinitrotoluene				4.0	10	10			480			
Endosulfan											1600	J 8.0
Ethyl Parathion	0.04			270		0.13						
Fluoranthene	10	10		2.0	10	42	1900	330	480	16000	330	
Fluorene				3.0	10	10	350	330	480	2000	J 330	
Gamma-BHC (Lindane)										50	8.0	
Hexachlorobenzene			0.01							440	J 330	
Indeno (1,2,3-cd) Pyrene							80	J	330	480	5000	J 330
Isophorone				1.0	10	10						
2-Methylnaphthalene				21	10		160	160		350	J 330	
2-Methylphenol				43	10					2300	330	
4-Methylphenol				160	10				380	2300	330	

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AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
SEMI-VOLATILES (TOTAL) (Continued)	(ug/L)			(ug/L)			(ug/kg)			(ug/kg)		
Naphthalene				25	10	10			480	1100	J	330
2-Nitrophenol	3.0	J	10									
4-Nitrophenol	2.0	J	50				180	J	1800			
4-Nitroaniline										5300	J	1800
N-Nitroso-di-n-Propylamine				5	10	10			480			
1-Nitrosodiphenylamine	162	*	10	300	10	10	880	J	330	2000	*	330
Pentachlorophenol	4.0	J	50	20	50	50	110	J	1800	350	J	1800
Phenanthrene				6.0	10	10	500	J	330	16000		330
Phenol	1.0	J	10	39	10	10	320	J	330	660	J	330
Prometon				0.09	0.03							
Prometryn				0.18	0.06							
Propazine				2.4	0.03							
Pyrene				4	10	10	880	J	330	19000		330
Simazine			0.004	330	0.06	4.0						
Simetryn				0.64	0.07							
Terbutylazine				1.4								
1,1,2,2-Tetrachloroethane							3		3			
1,2,4-Trichlorobenzene			0.01	4	10	700			480	4.0	J	330

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++ = Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (G.R.R.A.S.P.), v.1.1, 1990, EG&G Rocky Flats Environmental Restoration Program.

(a) = Plutonium 238 + 239 + 240

(b) = Radium 226 + 228

(c) = Ammonia as N

(d) = Sum of polychlorinated biphenyls (PCBs) in water

(e) = Based on Colorado Radiation Control Rules and Regulations, December 1985.

(f) = Site specific standards

TABLE 2-2

**ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-16
AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Concluded)**

Parameter	Groundwater			Surface Water			Soils			Sediments		
	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Preliminary TSBs	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{**}	Maximum ⁺	Minimum ⁺⁺	Background Concentration ^{***}
POLYCHLORINATED BIPHENYLS (PCBs) (µg/L)												
Aroclor-1254				12	1.0	1.0	440000		0.09	1800000	160	

NOTE:

Analytical data received prior to October 1988 not subjected to validation procedure. Some of the chemical values reported in this table have not yet been validated, and the analyte list may be changed after the data are validated.

* = Present in laboratory blank

** = Background concentrations taken from Draft Final Phase III RFP/RI Report, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1

*** = Background concentrations taken from Final Background Geochemical Characterization Report, Rocky Flats Plant, December, 1990.

J = Analyzed below detection limit

BR = Bedrock (including some weathered bedrock)

+ = Maximum concentration may be a one-time measurement. Values compiled from both recent and historic data, checked against Rocky Flats Environmental Data System.

++ = Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (G.R.R.A.S.P.), v.1.1, 1990, EG&G Rocky Flats Environmental Restoration Program.

(a) = Plutonium 238 + 239 + 240

(b) = Radium 226 + 228

(c) = Ammonia as N

(d) = Sum of polychlorinated biphenyls (PCBs) in water

(e) = Based on Colorado Radiation Control Rules and Regulations, December 1985.

(f) = Site specific standards

TABLE 5-1
RESIN TYPES AND CONTAMINANTS TREATED
OU 1 ION EXCHANGE PROCESS

Reactor No.	Resin Type	Contaminants Treated
1	Strong Base	Radionuclides
2	Weak Acid	Cations
3	Strong Acid	Metals
4	Weak Base	Anions

TABLE 5-2
REMOVAL EFFICIENCIES OF ORGANICS USING UV/H₂O₂ SYSTEM
UNDER FOUR TEST CONDITIONS

Analyte	Influent Concentration (ug/L)	Effluent Concentration (ug/L)	Percent Removal
Organics:			
Test No. 1			
Trichloroethene	21	< 5.0	76*
Tetrachloroethene	12	< 5.0	58*
Test No. 2			
Trichloroethene	16	< 5.0	69*
Tetrachloroethene	11	< 5.0	55*
Test No. 3			
Trichloroethene	16	< 5.0	69*
Tetrachloroethene	11	< 5.0	55*
Test No. 4			
Trichloroethene	16	< 5.0	69*
Tetrachloroethene	11	< 5.0	55*

- * Result based on instrument detection limit and represents minimum percent removal; the actual percent removal may be greater.

Test No. 1:

Flow rate: 15 gpm
Peroxide dose: 35 mg/L
No. of lamps: 16

Test No. 2:

Flow rate: 15 gpm
Peroxide dose: 50 mg/L
No. of lamps: 8

Test No. 3:

Flow rate: 15 gpm
Peroxide dose: 50 mg/L
No. of lamps: 8

Test No. 4:

Flow rate: 30 gpm
Peroxide dose: 50 mg/L
No. of lamps: 8

TABLE 5-3
REMOVAL EFFICIENCIES OF METALS AND INORGANICS USING
THE ION-EXCHANGE SYSTEM
OPERABLE UNIT 1 IRA

ANALYTE	INFLUENT CONCENTRATION (mg/L)	EFFLUENT CONCENTRATION (mg/L)	PERCENT REMOVED
Metals and Inorganics:			
Aluminum	<0.029	<0.029	-
Dissolved Aluminum	<0.029	<0.029	-
Arsenic	0.0029	<0.0007	76*
Dissolved Arsenic	0.0022	<0.0007	68*
Barium	0.16	<0.0038	98*
Dissolved Barium	0.16	<0.0038	98*
Calcium	74.9	0.12	99
Dissolved Calcium	74.9	0.11	99
Chromium	<0.002	0.0024	-
Dissolved Chromium	0.0036	0.0021	42
Copper	0.0040	<0.0023	43*
Dissolved Copper	0.0048	<0.0023	52*
Iron	0.099	0.065	34
Dissolved Iron	0.037	0.50	-
Lead	<0.0008	0.0024	-
Dissolved Lead	<0.0008	0.12	-
Lithium	0.01	<0.002	80*
Dissolved Lithium	0.013	<0.002	85*
Magnesium	18	0.084	99
Dissolved Magnesium	18	0.057	99
Manganese	0.0015	0.0015	0
Dissolved Manganese	0.0019	0.0015	21*
Molybdenum	<0.0035	<0.0035	-
Dissolved Molybdenum	<0.0036	<0.0035	-
Potassium	7.1	4.0	44

TABLE 5-3 (Continued)

ANALYTE	INFLUENT CONCENTRATION (mg/L)	EFFLUENT CONCENTRATION (mg/L)	PERCENT REMOVED
Dissolved Potassium	3.0	1.1	63
Selenium	0.014	<0.0008	94 _u
Dissolved Selenium	0.013	<0.0008	94 _u
Silicon	7.0	6.5	7
Dissolved Silicon	7.1	6.0	15
Sodium	64.6	16.4	74
Dissolved Sodium	65	15.1	77
Strontium	0.57	<0.0033	99 ^a
Dissolved Strontium	0.57	<0.0033	99 ^a
Vanadium	<0.0035	<0.0035	-
Dissolved Vanadium	0.0042	<0.0035	17 [*]
Zinc	0.43	0.0058	99
Dissolved Zinc	0.0067	0.0048	28
Miscellaneous:			
Bicarbonate	154	<10.0	95 ^a
Carbonate	<10.0	<10.0	-
Chloride	142	<10.0	86
Fluoride	0.86	0.67	22
Nitrate/Nitrite	7.7	55.1	-
Sulfate	48.5	<5.0	90 ^a
Total Dissolved Solids	464	70	85
Total Suspended Solids	5.5	<5.0	9 ^a

^a Value based on instrument detection range and represents minimum percent removal; actual percent removal may be higher.

TABLE 5-4
CONCENTRATION OF 1,2-DICHLOROETHANE ($\mu\text{g/l}$)
November 7, 1991 to January 9, 1992
OPERABLE UNIT 2 GAC TREATMENT

Date	Influent	Effluent
11/07/91	16.00	11.00
11/12/91	32.00	5.00 U
11/14/91	.	8.00
11/19/91	7.00	5.00 U
11/27/91	22.00	.
12/03/91	7.00	3.00 J
12/05/91	18.00	9.00
12/10/91	22.00 JA	2.00 JA
12/12/91	22.00 JA	2.00 JA
12/17/91	23.00 V	3.00 JA
12/19/91	28.00 V	5.00 UV
12/26/91	25.00 JA	4.00 JA
12/27/91	28.00 JA	4.00 JA
12/31/91	.	16.00 JA
01/02/92	25.00 JA	4.00 JA
01/07/92	25.00 V	4.00 JA
01/09/92	14.00 V	4.00 JA

Note: The preliminary TSB value is 5 $\mu\text{g/L}$.

QUALIFIER CODES:

U = Analyzed but not detected.

J = Reported Value is less than CRDL, but greater than IDL.

GENERAL CODES:

. = missing

VALIDATION CODES:

V = Valid. A = Acceptable. R = Rejected.

J = Associated numerical value is an estimated value.

TABLE 5-5

**COLLOID POLISHING FILTER TESTING
BENCH SCALE STUDY RESULTS⁽¹⁾**
(pCi/L)

Experiment ⁽²⁾		U-238	U-234	Pu-239	Am-241	Gross Alpha	Gross Beta
Run 1	INF	35.0 + 6.5	56.0 + 10	6.8 + 1.2	22.0 + 3.8	156 + 15	124 + 8
	EFF	-.01 + .03	-.03 + .03	-.01 + .02	-0.1 + .01	23 + 6	57 + 7
Run 2	INT	31.0 + 5.4	49.0 + 8.2	3.8 + .76	1.2 + .41	46 + 5	34 + 5
	EFF	-.01 + .03	.02 + .04	-.02 + .02	.043 + .03	17 + 5	54 + 9
Run 3 + S.S	INT	32.0 + 6.0	50.0 + 9.0	8.1 + 1.4	4.3 + .85	133 + 13	99 + 12
	EFF	.03 + .05	.04 + .06	-.02 + .01	.01 + .02	18 + 6	63 + 8
Run-4	INT	31.0 + 4.5	51.0 + 7.1	4.9 + .84	3.4 + 1.1	89 + 11	62 + 8
	EFF	.01 + .03	-0.2 + .03	-0.3 + .01	-0.1 + .02	21 + 5	55 + 9
Run-5	EFF	-.01 + .03	-0.1 + .04	-.02 + .02	-0.1 + .01	34 + 4	73 + 8
Run-6 Fast Flow Slow Flow	INF	12.0 + 2.2	18.0 + 3.3	22.0 + 3.5	26.0 + 3.8	82 + 8	44 + 8
	INT	7.5 + 1.2	12.0 + 2.0	9.0 + 1.3	6.0 + 1.2	42 + 5	20 + 7
	EFF-1	.01 + .03	.01 + .03	-0.1 + .02	.015 + .02	24 + 5	31 + 6
	EFF-2	.02 + .03	.01 + .03	-.01 + .02	.03 + .03	13 + 4	24 + 7
Run-7 Minerals	INT	11.0 + 2.1	17.0 + 3.1	14.0 + 2.3	(17 + 5.8)	85 + 9	42 + 6
	EFF	-0.1 + .03	-.01 + .04	.01 + .02	.059 + .052	19 + 5	34 + 7
Run-8	INT	3.3 + .82	5.1 + 1.1	6.1 + 1.0	9.2 + 2.4	46 + 8	35 + 8
	EFF	-.01 + .03	-.01 + .03	-.01 + .02	.05 + .04	14 + 3	31 + 5

⁽¹⁾ Tracers used: U-232 (4.7pc), Pu-242 94.0pc), Cm-244 (4.5pc).
200 ml was taken for INF and INT; 1 litre for EFF, Values in () shows poor yield.

⁽²⁾ See text for description of test conditions.

TABLE 6-1
ANNUAL REPORTS SUBMITTAL DATES - FYs 93, 94, AND 95
PROJECT SCHEDULE FY 93

PROJECT DESCRIPTION	PROJECT DATES	DELIVERABLE	SUBMITTAL SCHEDULE
FY 92 Sitewide Annual Report	10/92 - 3/93	Annual Report	March 8, 1993
FY 93 Sitewide Annual Report	10/93 - 3/94	Annual Report	March 14, 1994
FY 94 Sitewide Annual Report	10/94 - 3/95	Annual Report	March 13, 1995
Physical Separation	1/93 - 9/93	Treatability Study Report	October 1, 1993
Chemical Separation	11/92 - 6/93	Treatability Study Report	June 30, 1993
Potassium Ferrate Precipitation	3/93 - 9/93	Lab Testing Report	October 1, 1993
Colloidal Studies	10/92 - 8/93	Treatability Study Report	August 1, 1993
Adsorption	7/93 - 1994	Work Plan & Begin Treatability Study	TBD* 1994
Bioremediation	10/92 - 9/93	Literature Review	September 1, 1993
Colloid Polishing Filter Method	2/93 - 5/93	Lab Work and Report	December 1, 1993
Pondcrete Process Evaluation	2/93 - 7/93	Findings and Report	July 30, 1993

Note: Submittal dates for Fiscal Year Reports are IAG milestones; dates for other reports are only tentative.

• TBD - To Be Determined

APPENDIX A
TECHNOLOGY SELECTION AND SCREENING

APPENDIX A

SCREENING AND SELECTION OF TECHNOLOGIES

This FY 92 Annual Report provides a review, reevaluation, and rescreening of technologies identified in both the Final TSP and the FY 91 Annual Report for inclusion in the sitewide Treatability Studies Program. To this end, the FY 92 Annual Report presents new site characterization data, changes and/or additions to chemical-specific TSBs, and results of a literature search to identify potentially applicable technologies not previously considered for remediation efforts at the RFP. Also, all of the technologies originally considered for treatability testing under the Sitewide TSP have been reevaluated with regard to residuals generation. A summary of this reevaluation is included with Table A-1.

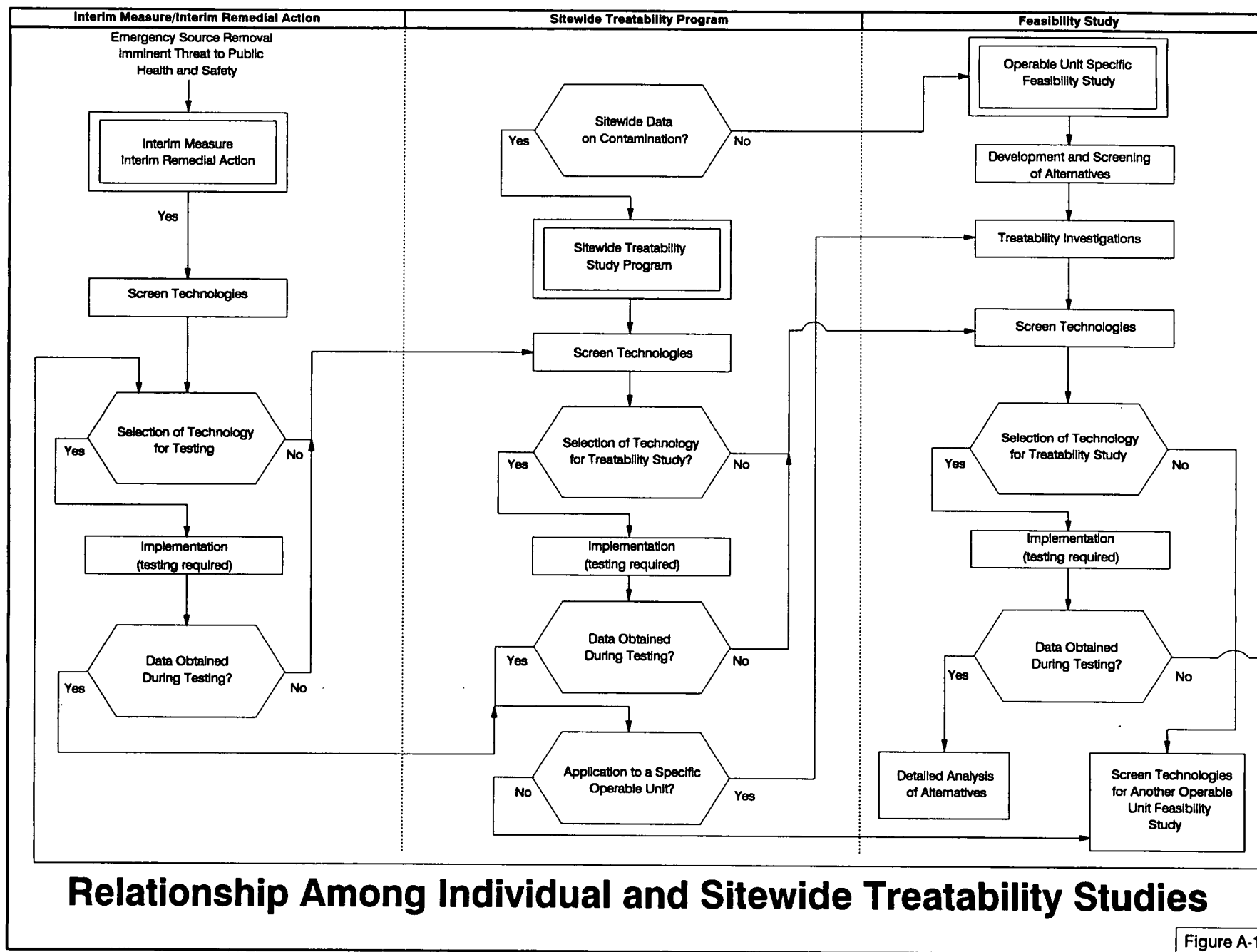
New technologies were identified and screened during preparation of the FY 92 Annual Report using the methodology identified in both the Final TSP and the FY 91 Annual Report. This section briefly reiterates the previously outlined methodology, and the recent technology screening effort.

● A decision process schematic was prepared in order to define the relationship among treatability study programs at RFP for individual OU and sitewide efforts. Figure A-1 shows this process, which graphically depicts management decision factors and their relation to the technology selection process. The process has three components for the screening effort, which include: (1) emergency source removal (completed under an Interim Measures/Interim Remedial Action (IM/IRA); (2) sitewide consideration of technologies; and (3) OU-specific consideration of technologies as part of the FS process.

A schedule of treatability studies has been determined. Technologies that were screened in FY 92 that have met the additional administrative constraints were selected for treatability study projects. Funding and project dates have been set according to funding priorities and project time restrictions.

A.1 TECHNOLOGY SELECTION PROCESS

The site characterization data were reviewed and compared to available potential TSBs in order to identify major contaminant types and associated media that exist at RFP. This review focused on data newly incorporated into RFEDS during the period between completion of the Draft FY 91 Annual Report and September 1992. A literature/database search was conducted to identify new or innovative technologies not previously described, and new information on existing technologies potentially applicable to the contaminant types and medium identified in more than one OU.



Technologies identified from the literature/database search were subjected to a two-step screening process. Technologies were selected for screening if they had not been evaluated in the Final TSP or the FY 91 Annual Report, or if new information was available regarding their potential performance. The first step, preliminary screening, identified technologies suitable for consideration as part of the RFP sitewide TSP using screening criteria described in detail in Section A.1.3. The second step, final screening, evaluated whether those technologies passing the preliminary screening and deemed appropriate for final screening would provide beneficial information to the sitewide TSP. In other words, a judgment was made as to whether treatability testing would be needed to evaluate the technology under consideration. The two-step screening method is illustrated in Figure A-2 and described in Sections A.1.3 and A.1.4. Statements of Work (SOWs) were prepared for new technologies selected for treatability testing during the screening process.

A.1.1 Site Characterization Data and Potential TSBs Review

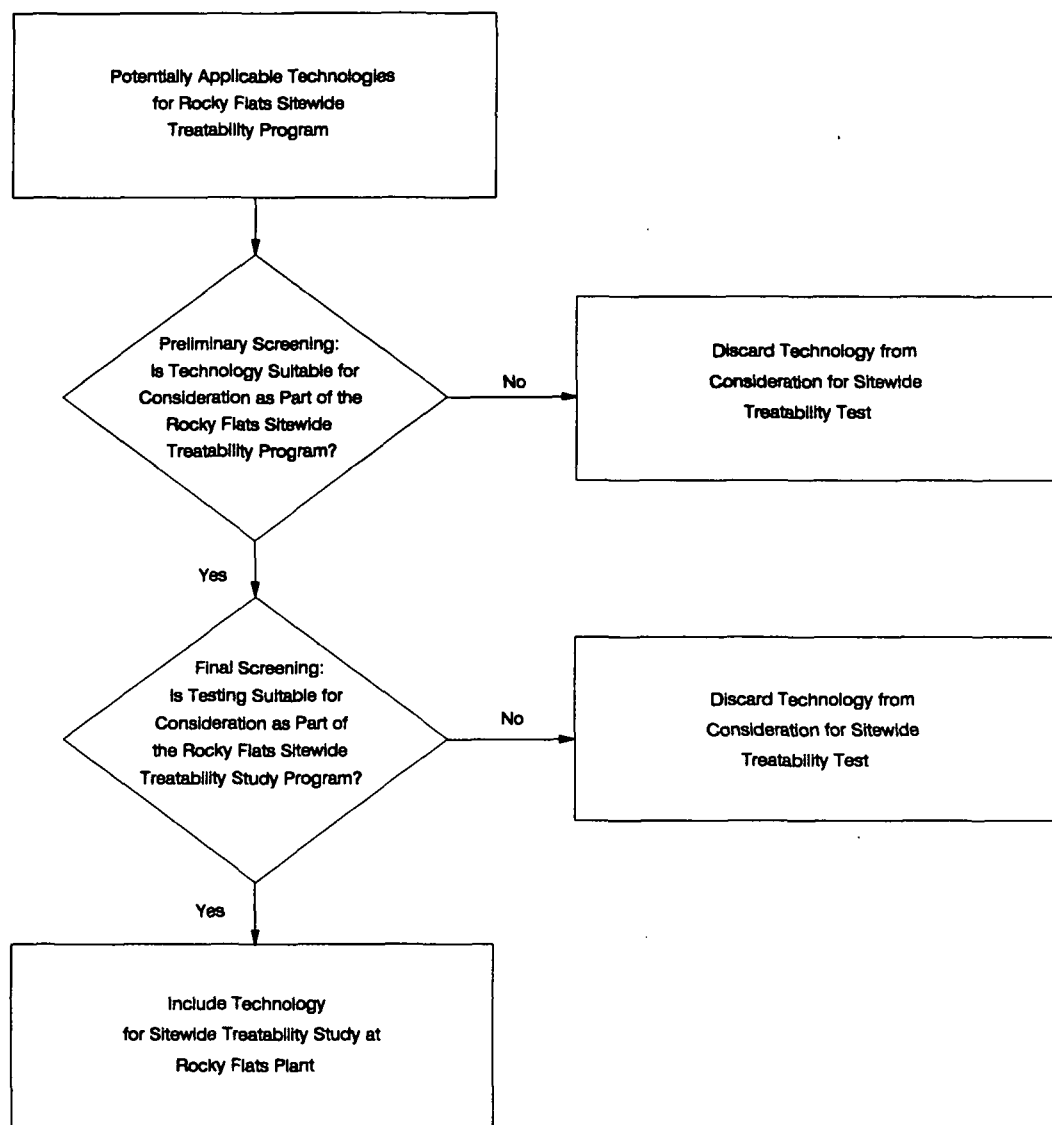
The site characterization data and potential TSBs were updated and reviewed, as previously described in Sections 2 and 3, respectively. The contaminants identified during the review of site characterization data were grouped in broad categories by contaminant type (e.g., volatile organics, radionuclides) and medium (e.g., groundwater, surface water).

A.1.2 Technology Data Review

The review of technology data included an investigation of the status of ongoing treatability test programs and interim remedial actions at RFP, and a search for new information on potentially applicable technologies. The status of treatability tests and interim actions in progress at RFP was summarized in Section 5.0. Sources of new information on potentially applicable technologies include literature/database searches, reviews of conference proceedings, EPA guidance documents, DOE reports, and vendor supplied materials. Overall, the technology data review was primarily focused on: (1) treatment technologies that are applicable to existing contaminant categories, including technologies previously screened; and, (2) technologies that were not considered in the Final TSP and FY 91 Annual Report but are appropriate for screening in the FY 92 Annual Report based on information regarding treatment performance capability.

A.1.3 Preliminary Screening Process

A preliminary screening of treatment technologies identified as being applicable to the major contaminant categories was performed. This screening resulted in the selection of technologies considered suitable for further consideration as part of the RFP sitewide TSP. The following criteria



Treatment Technology Screening Process Rocky Flats Sitewide Treatability Program

Figure A-2

were applied in screening technologies:

- Potential applicability to new major contaminant categories that were identified during review of new site characterization data
- Potential applicability to any major contaminant category, including categories previously identified (this criterion resulted in new technologies being introduced for screening)
- Innovative technologies for which new information was available on performance capabilities as identified from ongoing or completed testing at RFP.
- Technology applicability to contaminant categories to more than one OU.

New technologies identified and technologies applicable to existing contaminant categories were included in the preliminary screening process. No new contaminant categories were identified at RFP during FY 92. Technology description summaries were prepared for each technology included in the screening process. These detailed summaries are presented in Appendix D.

A.1.4 Management Decision Factors

Management decision factors include such things as the following: 1) State and community acceptance, 2) Schedule constraints, 3) Budget constraints, and 4) Weighting factors for the technology screening criteria.

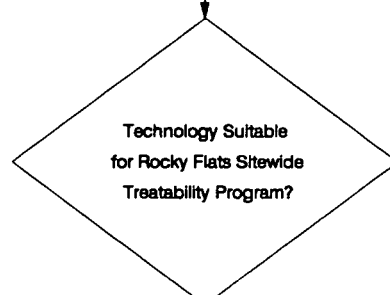
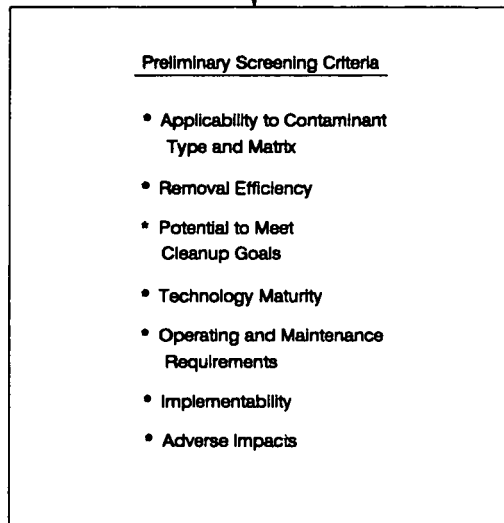
State and community acceptance are important factors and Environmental Restoration Management must be aware of how potential treatability processes are regarded by the community. Testing a technology which would not be acceptable to the community would be misuse of resources.

Budget and schedule constraints are obvious factors. If there is not sufficient funding or time to for testing of all of the selected technologies, Environmental Restoration Management will select the technologies which will be tested.

The preliminary screening process is illustrated in Figure A-3. Criteria used for the preliminary screening process include:

- Applicability
- Removal efficiency
- Potential to meet cleanup goal
- Technology maturity
- O&M requirements
- Implementability
- Adverse impacts

Potentially Applicable
Technologies for
Rocky Flats Sitewide
Treatability Program



No

Discard Technology
From Consideration for
Sitewide Treatability Test

Yes

Screen Technology for
Suitability for Bench,
Lab, or Pilot Testing
at Rocky Flats

Treatment Technology Preliminary Screening Rocky Flats Sitewide Treatability Study Program

How these criteria are weighted in the selection process is a part of the management decision factor. The screened technology will be ranked in one order if all the criteria are considered to have equal weight. The same list of screened technologies could be ranked in a different order if the selection criteria were weighted differently. As the environmental remediation process matures at RFP some of the criteria may become more important than they were originally. This could result in changes in ranking of screened technologies. How the criteria are weighted for use in the technology screening process is part of the management decision process.

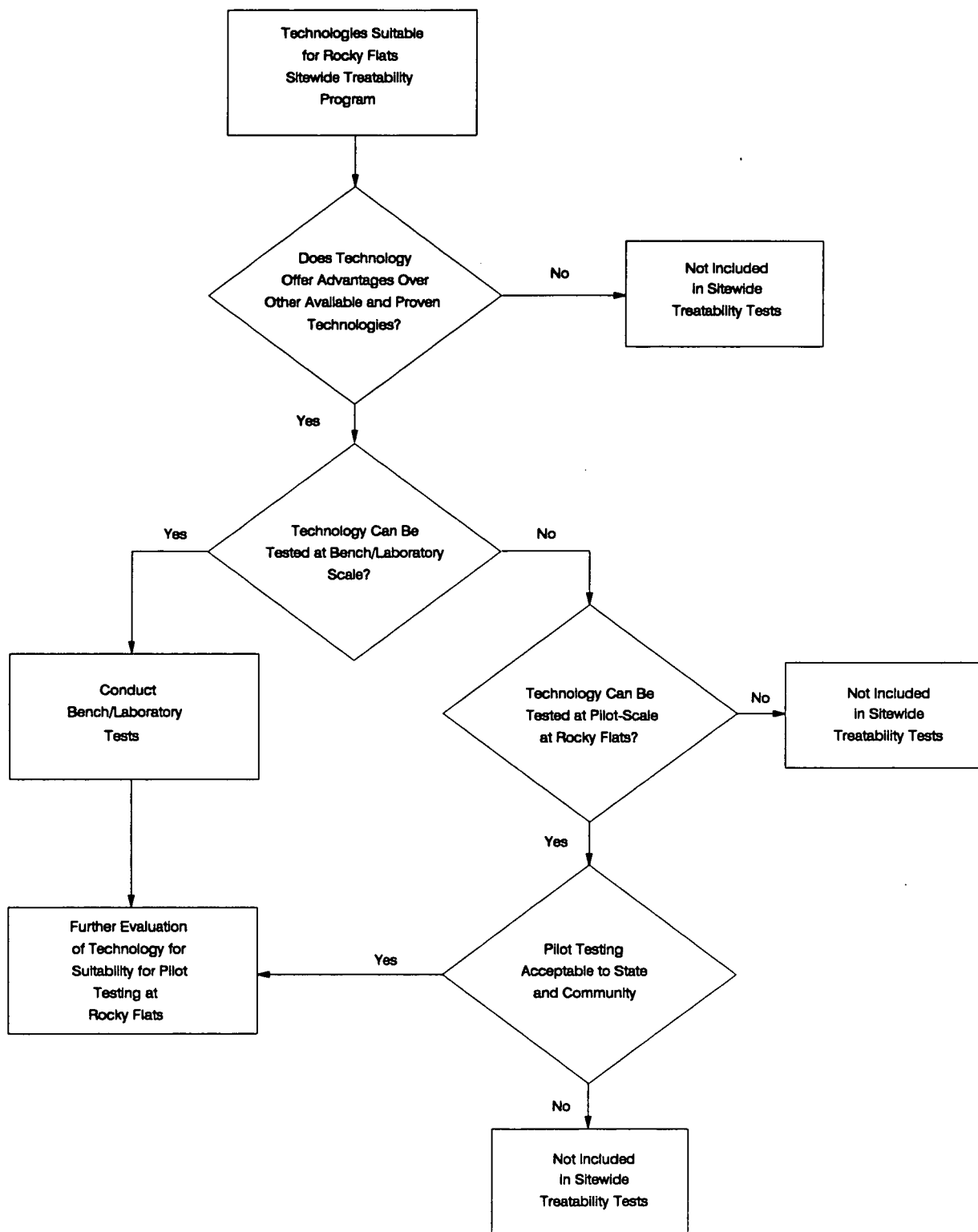
A.1.5 Final Screening Process

The final screening process illustrated in Figure A-4 selected technologies potentially applicable for use in the RFP Treatability Study Program. The overall objective of final screening is to review and update the technology selection completed in the Final TSP and the FY 91 Annual Report. The final screening applies to: (1) technologies retained following the preliminary screening; (2) technologies for which new significant information has become available since their initial consideration in the final screening process of the Final TSP; and, (3) technologies which were retained in the Final TSP or FY 91 Annual Report after preliminary screening and were not subjected to the final screening because analytes exceeding potential TSBs were not identified in more than one OU in the Final TSP (these technologies were subjected to a final screening based on the updated review of potential TSBs and contamination data in the FY 92 Annual Report). Technologies subjected to the screening process include: (1) radio frequency heating; (2) manganese dioxide adsorption; (3) reverse burn gasification; (4) electrokinetic remediation; and, (5) supercritical carbon dioxide extraction treatment. All of the technologies evaluated as part of the FY 92 Annual Report would require no more than bench- or laboratory-scale testing. As noted in Figure A-3, special consideration regarding State or community acceptance is given to those technologies deemed appropriate for pilot-scale testing. This particular criterion was not applicable for technologies considered in the FY 92 Annual Report.

SOWs were prepared for new technologies selected through final screening. These SOWs are included in Appendix E of this report and supplement SOWs prepared for the Final TSP and the FY 91 Annual Report. An order-of-magnitude cost estimate was prepared for treatability testing of identified technologies to serve as an input into decisions regarding priority and scheduling of tests.

A.1.6 Pilot and Bench Testing Evaluation

The process for evaluating suitability of technologies for pilot-scale testing is presented in Figure A-5. This procedure, adapted from the EPA guidance document for conducting treatability studies, was designed to allow the continuous evaluation of new information for each technology



Treatment Technology Final Screening Process Rocky Flats Sitewide Treatability Study Program

Figure A-4

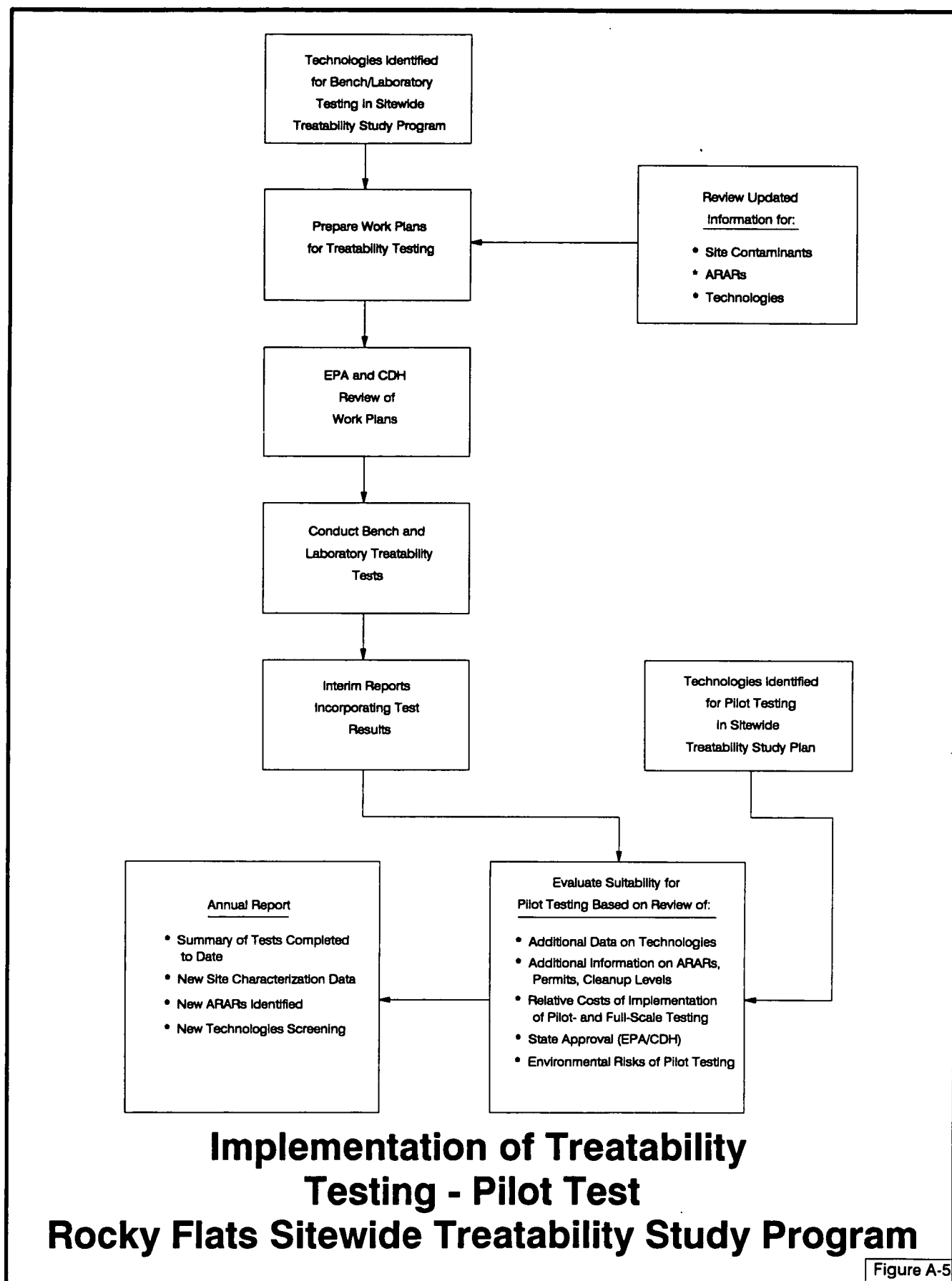


Figure A-5

based on bench-scale testing and a literature search through the life of the treatability program. Technologies selected for bench- and/or pilot-scale testing in the Final TSP and the Fiscal Year Annual Reports will be reevaluated annually. The review will include additional information on potential TSBs, permits, cleanup levels, agency approval, and environmental risks of pilot testing. Relative costs for implementing a program for pilot- and full-scale testing will be prepared as appropriate.

A.2 TECHNOLOGIES EVALUATION AND SELECTION SUMMARY

This section presents results of the technology selection process for technologies that are appropriate for inclusion in the sitewide TSP. The technologies which were preliminarily screened are presented in Section A.2.1. The final technology screening process results are presented in Section A.2.2.

A technology data summary was prepared for each treatment technology subjected to screening in the FY 92 Annual Report. Data summaries for groundwater/surface water and soils/sediments treatment technologies are included in Appendix D. An SOW was prepared for the one technology selected for testing and is presented in Appendix E.

A.2.1 Preliminary Screening

Table A-2 provides a summary of the preliminary screening of technologies considered for incorporation into the sitewide TSP. Three of these technologies, RF heating, electrokinetic remediation, and supercritical carbon dioxide extraction, were considered previously in the Final TSP and/or the FY 91 Annual Report. These technologies were reevaluated for reasons noted on Table A-2. The remaining two technologies, manganese dioxide adsorption and reverse burn gasification, are new technologies (not previously considered) that are potentially applicable to remediation efforts at RFP. Consideration of these new technologies does not stem from the discovery of new contaminants/media at RFP; rather, their consideration is due information collected during preparation of the FY 92 Annual Report which revealed their potential applicability to treatment of previously identified contaminants and media. Their consideration in this report supplements those technologies investigated during the Final TSP and the FY 91 Annual Report.

RF heating was the only technology retained for final screening. Manganese dioxide adsorption, reverse burn gasification, electrokinetic remediation, and supercritical carbon dioxide extraction were eliminated during the screening process due to each being in a very early stage of development, having unknown performance characteristics, having difficulties with implementation,

and/or having expected difficulties with scale-up. Upon investigation, RF heating offered the greatest promise of contributing to remediation efforts at RFP considering: (1) availability of vendors to provide bench- to pilot-scale systems; (2) principle of operation; (3) minimal impacts on the environment at RFP; (4) relative ease of implementation; and, (5) its adaptability to a wide variety of field conditions.

A.2.2 Final Screening

Treatability testing of RF heating (see Appendix D for detailed technology description) would provide a significant amount of information needed to fully evaluate the technology for its potential applicability to organic-contaminated RFP soils or sediments. Tests beginning with bench-laboratory-scale efforts on subsurface soil samples from the RFP would provide definition of antennae spacing requirements for an in situ remediation effort, as well as an indication of electrical utility requirements for a pilot- or full-scale application. Depending on the results of laboratory-bench-scale tests, a pilot-scale demonstration may be warranted, particularly in an area where a pilot-scale unit could benefit on an interim basis the overall remediation of a contaminated area (e.g., IHSS 119.1 of OU 1). This concept of an interim pilot-scale effort for interim remedial action is being implemented for subsurface soils at OU 2, as described in Section 5.

A.3 EVALUATION OF THE TECHNOLOGY SELECTION PROCESS

A peer review of the technology screening process which was used to screen technologies for the Final Sitewide Plan is currently being performed. The purpose of this review is to seek ways to improve the selection process and then use the improved screening process to re-screen all of the candidate technologies. Some technologies which were previously rejected may be selected by the improved screening and selection process. This study is scheduled to be completed during the spring of 1993 and the results will be included in the annual report for FY 93. Results will include a list of advantages for each of the technologies selected during the re-screening process.

TABLE A-1

RESIDUALS GENERATION FOR TECHNOLOGIES
SELECTED FOR TREATABILITY STUDIES

TECHNOLOGY	APPLICATION	RESIDUALS	DISCUSSION
<ul style="list-style-type: none"> • Adsorption 	<ul style="list-style-type: none"> • Removal of metals and/or radionuclides from water 	<ul style="list-style-type: none"> • Solid Adsorbent • Regeneration Stream 	<ul style="list-style-type: none"> • The volume of residuals is dependent on several factors including suspended solids loading on the absorber material (heavy solids loading would require frequent changeout), cleanup levels required, properties of targeted contaminant, etc. Regeneration stream residuals are dependent on regeneration mechanism utilized (e.g., solvent flushing, thermal, biological). In general, residual generation is moderate relative to technologies serving similar treatment capacity.
<ul style="list-style-type: none"> • Ion Exchange 	<ul style="list-style-type: none"> • Removal of metals and/or radionuclides from water 	<ul style="list-style-type: none"> • Ion Exchange Resin • Regeneration Stream 	<ul style="list-style-type: none"> • Residuals can be minimized by utilizing ion exchange resin that is specific for the targeted ionic contaminant species. Volumes of flushing solutions are dependent on frequency of flushing and concentration of flushing solution. In general, residual generation is moderate relative to technologies serving similar treatment capacity.

TABLE A-1 (Continued)

TECHNOLOGY	APPLICATION	RESIDUALS	DISCUSSION
• Oxidation/Reduction	• Destruction of metals and/or radionuclides in water	• Sludge	• Residual generation is highly dependent on contaminant type and concentration, oxidizing and reducing agent, and reaction characteristics. Those reactions leading to precipitation events generate sludge. Other reactions may generate by-products requiring further treatment. In general oxidation/reduction treatment results in low residual generation.
• TRUclear (Potassium Ferrate Precipitation)	• Removal of radionuclides from liquid streams.	• Sludge	• Residual generation is dependent on concentration of contaminant being precipitated and amount of potassium ferrate added. Generally, since radionuclide concentrations in water are low (by mass), sludge generation will be very low.
• Ultrafiltration/ Microfiltration	• Removal of radionuclides from liquid streams.	• Solids (Filter Media) • Concentrated (possibly brine) stream	• Residual generation is dependent on suspended solids loading of stream being treated. Also, with ultrafiltration, some dissolved materials may come out of solution and concentrate with filtrate. Actual filtering media contributes significantly to overall volume of residuals. In general, these technologies have relatively high residuals generation.

TABLE A-1 (Continued)

TECHNOLOGY	APPLICATION	RESIDUALS	DISCUSSION
<ul style="list-style-type: none"> Physical Separation 	<ul style="list-style-type: none"> Removal of metals and/or radionuclides from soils and sediments. 	<ul style="list-style-type: none"> Sludge (for wet applications) 	<ul style="list-style-type: none"> A sludge is generated for physical separation processes utilizing a slurried waste stream. Dry physical separation produces very little residual material if contaminant isolation is efficient.
<ul style="list-style-type: none"> Polymerization stabilization 	<ul style="list-style-type: none"> Stabilization of metals and/or radionuclides in soils and sediments. 	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Although residual waste streams are not generated, polymerization stabilization does result in a net volume increase in contaminated material.
<ul style="list-style-type: none"> Portland Cement Stabilization 	<ul style="list-style-type: none"> Stabilization of metals and/or radionuclides in soils and sediments 	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Although residual waste streams are not generated, cement-based solidification does result in a net volume increase in contaminated material.
<ul style="list-style-type: none"> Soil Washing 	<ul style="list-style-type: none"> Removal of metals and/or radionuclides from soils and sediments 	<ul style="list-style-type: none"> Liquids with contaminants 	<ul style="list-style-type: none"> Soil washing generates a liquid (usually aqueous) containing the targeted soil or sediment contaminant. Further residuals may be generated upon the treatment of the liquid stream. Generally, residuals generation from soil flushing is low, but it does vary with the type of liquid treatment selected.

TABLE A-1 (Continued)

TECHNOLOGY	APPLICATION	RESIDUALS	DISCUSSION
<ul style="list-style-type: none"> • Magnetic Separation 	<ul style="list-style-type: none"> • Removal of radionuclides from soils and sediments 	<ul style="list-style-type: none"> • Liquids (for slurried application) • Matrix (typically stainless steel wool) for high gradient magnetic separation 	<ul style="list-style-type: none"> • Dry applications produce no residuals. Slurried applications produce a liquid stream that may contain low levels of contaminant depending on the performance of magnetic separation. High gradient magnetic separation produces a contaminated matrix material (contamination is targeted contaminant), although matrix volume is very low. Overall, magnetic separation produces very low volumes of residual material.
<ul style="list-style-type: none"> • Masonry Cement Stabilization 	<ul style="list-style-type: none"> • Stabilization of metals and/or radionuclides in soils and sediments. 	<ul style="list-style-type: none"> • None 	<ul style="list-style-type: none"> • Although residual waste streams are not generated, cement-based solidification does result in a net volume increase in contaminated material.

TABLE A-1 (Continued)

TECHNOLOGY	APPLICATION	RESIDUALS	DISCUSSION
<ul style="list-style-type: none"> • TRUclean 	<ul style="list-style-type: none"> • Removal of radionuclides from soils and sediments 	<ul style="list-style-type: none"> • Liquid with suspended solid contaminants and possibly dissolved contaminants • Sludge 	<ul style="list-style-type: none"> • Generally, TRUclean is used to isolate targeted solids (such as plutonium in soils) by providing collection of materials based on differing densities and settling rates. The liquid (water) medium is recycled; thus, a limited amount of water must be treated (usually filtration to remove all suspended solids) prior to discharge. Residuals generation is dependent on the number and type of unit operations utilized for target contaminant isolation. At high process efficiencies, the final sludge product is of very low volume.
<ul style="list-style-type: none"> • Ozonation 	<ul style="list-style-type: none"> • Destruction of VOCs in groundwater and surface water. 	<ul style="list-style-type: none"> • Effluent may contain low molecular weight chlorinated solvents. 	<ul style="list-style-type: none"> • Ozonation is not effective on low molecular weight chlorinated solvents. If this type of chlorinated solvent is present in the waste stream being treated, then the effluent from the ozonation process may require further treatment.
<ul style="list-style-type: none"> • Peroxide Oxidation and Ultraviolet Oxidation 	<ul style="list-style-type: none"> • Destruction of VOCs in groundwater and surface water 	<ul style="list-style-type: none"> • Effluent may contain hazardous reaction by-products 	<ul style="list-style-type: none"> • A completely efficient oxidation process results in complete breakdown of VOCs in water. Reaction products will be carbon dioxide and water. Lower efficiency may result in by-product that includes shorter chain hydrocarbons.

TABLE A-1 (Continued)

TECHNOLOGY	APPLICATION	RESIDUALS	DISCUSSION
<ul style="list-style-type: none">• Ultraviolet Photolysis	<ul style="list-style-type: none">• Destruction of VOCs in groundwater and surface water.	<ul style="list-style-type: none">• Effluent may contain hazardous reaction by-products	<ul style="list-style-type: none">• Photochemical reaction products may be more hazardous than the original hazardous constituent(s) targeted for UV treatment.

TABLE A-2
PRELIMINARY TREATMENT TECHNOLOGY SCREENING
ROCKY FLATS SITEWIDE TREATABILITY PROGRAM

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O & M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Radio Frequency Heating ⁽¹⁾	In situ remediation of VOCs SVOCs in soils or other contaminated media. Thermal Process.	> 95 % expected	Moderate	Innovative, but commercially available	Expected to be moderate due to significant amount of support equipment.	Should be easily implemented. Low impact to area.	Residuals. As with all in situ treatment technologies, cleanup verification is uncertain.	Yes
Manganese Dioxide Adsorption	Isolation of radionuclides from aqueous streams.	65 - 85 %	Low-Moderate	Innovative; Still in laboratory study stage	Unknown	Many parameters such as competition for adsorption among various ionic species is unknown.	Residuals.	No
Reverse Burn Gasification	Destruction of organics contained in a wide variety of media. "Ex Situ"	99.9999 %	High	Bench-Scale level of development	Expected to be high due to complexity of equipment, need for excavation, and need for continuous supply of char.	Difficult to implement due to very early stage of development.	Requires material excavation; cannot be implemented in situ.	No
Electrokinetic Remediation ⁽²⁾	Remediation of heavy metal contaminated soils. Some recent success with organics in soil.	Unknown	Unknown	Emerging Technology	Expected to be high due to complexity and needed support equipment.	Would be difficult to implement due to very early stage of development.	No known significant adverse impacts.	No
Supercritical Carbon Dioxide ⁽³⁾	Extraction of metals, radionuclides, and organics from complex matrices (e.g., soil).	Unknown	Unknown	Emerging Technology	Expected to be moderate.	May be difficult to scale up effectively.	Requires material excavation; cannot be implemented in situ.	No

⁽¹⁾ Radio Frequency Heating was originally selected for the sitewide Treatability Study Program during preparation of the Final TSP. The FY 92 Annual Report reevaluates radio frequency heating since it is a potential technology that is under consideration for VOCs removal from subsurface soils at OU1.

⁽²⁾ Electrokinetic Remediation was screened out in the Final TSP. It was reconsidered during preparation of the FY 92 Annual Report due to evidence of limited success with mobilizing benzene, toluene, ethylene, xylene, and trichloroethylene in soil.

⁽³⁾ Carbon dioxide adsorption was previously considered for adsorption of organics only. The technology was reevaluated based on its potential for adsorption of metals and radionuclides.

APPENDIX B
FY 92 RFEDS DATA, AND PRELIMINARY
CHEMICAL-SPECIFIC TSBs FOR THE SITEWIDE
TREATABILITY STUDIES PROGRAM

APPENDIX B
FY 92 RFEDS DATA, AND PRELIMINARY
CHEMICAL-SPECIFIC TSBs FOR THE SITEWIDE
TREATABILITY STUDIES PROGRAM

Table B-1 FY92 RFEDS Operable Unit 1 Analytical Data

OU1 - GROUNDWATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	3	3	25000	6900	UG/L
1,1,2,2-TETRACHLOROETHANE	1	1	3	3	UG/L
1,1,2-TRICHLOROETHANE	3	3	120	73	UG/L
1,1-DICHLOROETHANE	3	3	500	150	UG/L
1,1-DICHLOROETHENE	3	3	11000	7200	UG/L
1,2-DICHLOROETHANE	3	3	25	16	UG/L
1,2-DICHLOROETHENE	3	3	14000	31	UG/L
2-BUTANONE	3	3	580	19	UG/L
4-METHYL-2-PENTANONE	1	1	3	3	UG/L
ACETONE	3	3	400	170	UG/L
ALUMINUM	6	6	31400	20.8	UG/L
AMERICIUM-241	3	3	0.007569	0.004259	PCI/L
ANTIMONY	4	4	60	6	UG/L
ARSENIC	9	9	18.2	4	UG/L
BARIUM	6	6	502	44.9	UG/L
BENZENE	6	6	2	1	UG/L
BENZOIC ACID	1	1	14	14	UG/L
BERYLLIUM	9	9	3	1	UG/L
BICARBONATE	4	4	600000	499000	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	2	2	2	1	UG/L
BROMOMETHANE	1	1	1	1	UG/L
CADMIUM	10	10	13.8	0.4	UG/L
CALCIUM	6	6	316000	40214.1	UG/L
CARBON DISULFIDE	9	9	11	1	UG/L
CARBON TETRACHLORIDE	3	3	6600	450	UG/L
CARBONATE	3	3	43200	6930	UG/L
CHLORIDE	3	3	580000	379000	UG/L
CHLOROETHANE	2	2	10	8	UG/L
CHLOROFORM	3	3	110	73	UG/L
CHROMIUM	5	5	47.3	10.1	UG/L
COBALT	3	3	49.5	35.5	UG/L
COPPER	4	4	3130	6.2	UG/L
CYANIDE	1	1	9.5	9.5	UG/L
DI-n-BUTYL PHTHALATE	3	3	3	1	UG/L
DIETHYL PHTHALATE	3	3	4	2	UG/L
ETHYLBENZENE	3	3	6	2	UG/L
IRON	4	4	5820	49	UG/L
LEAD	7	7	9.2	0.3	UG/L
LITHIUM	15	15	588	50	UG/L
MAGNESIUM	6	6	105000	11349.8	UG/L
MANGANESE	5	5	3330	9.4	UG/L
MERCURY	4	4	0.29	0.1	UG/L
METHYLENE CHLORIDE	3	3	200	130	UG/L
MOLYBDENUM	3	3	185	39.8	UG/L
N-NITROSODIPHENYLAMINE	2	2	12	8	UG/L
NICKEL	4	4	11700	23.4	UG/L
NITRATE/NITRITE	5	5	41700	39500	UG/L
PLUTONIUM-239/240	2	2	0.002704	0.001888	PCI/L
POTASSIUM	3	3	13200	10400	UG/L
SELENIUM	11	11	2370	3	UG/L
SILVER	3	3	10.6	2.1	UG/L
SODIUM	6	6	271000	79433.1	UG/L
STRONTIUM	6	6	3410	485.3	UG/L
STRONTIUM-89,90	3	3	0.5156	0.4193	PCI/L
SULFATE	3	3	795000	692000	UG/L
TETRACHLOROETHENE	3	3	8100	3800	UG/L
THALLIUM	3	3	1.5	1.1	UG/L
TIN	1	1	121	121	UG/L
TOLUENE	3	3	110	28	UG/L
TOTAL DISSOLVED SOLIDS	3	3	1887000	1765000	UG/L
TOTAL SUSPENDED SOLIDS	4	4	2300000	670000	UG/L
TOTAL XYLENES	6	6	2	0.8	UG/L
TRICHLOROETHENE	3	3	17000	6500	UG/L
TRITIUM	3	3	314.1	277.7	PCI/L
URANIUM-235	3	3	0.5948	0.2885	PCI/L
VANADIUM	3	3	57.5	44.4	UG/L
VINYL CHLORIDE	2	2	13	9	UG/L
ZINC	6	6	970	12.7	UG/L
beta-BHC	1	1	0.055	0.055	UG/L

Table B-1 (continued)

OU1 - SOIL BORINGS

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,3-DICHLOROBENZENE	1	1	180	180	UG/KG
1,4-DICHLOROBENZENE	3	3	110	82	UG/KG
2-BUTANONE	4	4	1000	5	UG/KG
4-METHYL-2-PENTANONE	2	2	2000	2	UG/KG
ACENAPHTHENE	2	2	57	57	UG/KG
ACETONE	5	5	39000	30	UG/KG
ALUMINUM	3	3	13100000	10900000	UG/KG
ANTHRACENE	3	3	81	46	UG/KG
ANTIMONY	1	1	16200	16200	UG/KG
ARSENIC	3	3	8900	7400	UG/KG
BARIUM	4	4	250000	35	UG/KG
BENZO(a)ANTHRACENE	3	3	110	66	UG/KG
BENZO(a)PYRENE	2	2	130	3	UG/KG
BENZO(b)FLUORANTHENE	3	3	89	61	UG/KG
BENZO(ghi)PERYLENE	1	1	50	50	UG/KG
BENZO(k)FLUORANTHENE	3	3	180	35	UG/KG
BENZOIC ACID	2	2	2000	110	UG/KG
BERYLLIUM	12	12	17800	0.6	UG/KG
BIS(2-ETHYLHEXYL)PHTHALATE	7	7	1500	1300	UG/KG
CADMIUM	1	1	1800	1800	UG/KG
CALCIUM	3	3	14100000	11000000	UG/KG
CARBON DISULFIDE	3	3	1	1	UG/KG
CESIUM	3	3	234000	3400	UG/KG
CHLOROBENZENE	1	1	6	6	UG/KG
CHLOROFORM	5	5	3	3	UG/KG
CHROMIUM	3	3	17700	15000	UG/KG
CHRYSENE	3	3	150	72	UG/KG
COBALT	6	6	15300	6.6	UG/KG
COPPER	3	3	28000	24300	UG/KG
DI-n-BUTYL PHTHALATE	3	3	630	520	UG/KG
DI-n-OCTYL PHTHALATE	3	3	250	44	UG/KG
FLUORANTHENE	3	3	290	200	UG/KG
FLUORANTHENE	3	3	290	200	UG/KG
FLUORENE	2	2	55	54	UG/KG
GROSS ALPHA - DISSOLVED	1	1	14	14	PCI/G
GROSS BETA - DISSOLVED	1	1	20	20	PCI/G
INDENO(1,2,3-cd)PYRENE	1	1	47	47	UG/KG
IRON	3	3	38100000	13200000	UG/KG
LEAD	3	3	29900	22000	UG/KG
LITHIUM	3	3	12200	9000	UG/KG
MAGNESIUM	3	3	5600000	5350000	UG/KG
MANGANESE	3	3	511000	367000	UG/KG
MERCURY	2	2	110	100	UG/KG
METHYLENE CHLORIDE	6	6	9000	34	UG/KG
MOLYBDENUM	3	3	13900	4200	UG/KG
N-NITROSODIPHENYLAMINE	3	3	370	250	UG/KG
NICKEL	6	6	32100	5.5	UG/KG
NITRATE/NITRITE	6	6	1200	1100	UG/KG
PENTACHLOROPHENOL	2	2	85	41	UG/KG
PHENANTHRENE	3	3	310	180	UG/KG
PLUTONIUM-239/240	3	3	0.019	0.005	PCI/G
POTASSIUM	6	6	1700000	813	UG/KG
PYRENE	3	3	270	240	UG/KG
SILVER	3	3	2700	2400	UG/KG
SODIUM	7	7	890000	603	UG/KG
STRONTIUM	3	3	141000	94200	UG/KG
STRONTIUM-89,90	1	1	0.35	0.35	PCI/G
SULFIDE	7	7	3000	2000	UG/KG
THALLIUM	3	3	350	290	UG/KG
TOLUENE	5	5	460000	460	UG/KG
TRICHLOROETHENE	1	1	3	3	UG/KG
URANIUM-233,-234	3	3	1.2	0.9	PCI/G
URANIUM-235	3	3	0.086	0.039	PCI/G
URANIUM-238	3	3	1.5	0.95	PCI/G
VANADIUM	3	3	38100	30300	UG/KG
ZINC	3	3	111000	78200	UG/KG

Table B-1 (continued)

OU1 - SEDIMENT

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	1	1	3	3	UG/KG
2-BUTANONE	2	2	14	3	UG/KG
4-METHYLPHENOL	2	2	2200	510	UG/KG
ACETONE	4	4	6000	100	UG/KG
ALUMINUM	3	3	24800000	11900000	UG/KG
ARSENIC	3	3	5500	4800	UG/KG
BARIUM	3	3	300000	185000	UG/KG
BENZO(b)FLUORANTHENE	1	1	190	190	UG/KG
BENZO(k)FLUORANTHENE	1	1	110	110	UG/KG
BENZOIC ACID	1	1	390	390	UG/KG
BERYLLIUM	3	3	15500	6900	UG/KG
BIS(2-ETHYLHEXYL)PHTHALATE	3	3	1300	760	UG/KG
BUTYL BENZYL PHTHALATE	1	1	57	57	UG/KG
CALCIUM	3	3	56700000	14900000	UG/KG
CARBON DISULFIDE	1	1	6	6	UG/KG
CESIUM	1	1	2230	2230	UG/KG
CHLOROFORM	1	1	18	18	UG/KG
CHLOROMETHANE	2	2	60	19	UG/KG
CHROMIUM	3	3	26800	14400	UG/KG
CHRYSENE	1	1	190	190	UG/KG
COBALT	2	2	8200	6400	UG/KG
COPPER	3	3	36300	19900	UG/KG
DI-n-BUTYL PHTHALATE	3	3	700	300	UG/KG
ETHYLBENZENE	1	1	4	4	UG/KG
FLUORANTHENE	2	2	380	120	UG/KG
FLUORANTHENE	2	2	380	120	UG/KG
IRON	3	3	28900000	19100000	UG/KG
LEAD	3	3	66400	22500	UG/KG
LITHIUM	4	4	27800	7600	UG/KG
MAGNESIUM	3	3	5970000	4060000	UG/KG
MANGANESE	2	2	484000	171000	UG/KG
METHYLENE CHLORIDE	4	4	11000	22	UG/KG
MOLYBDENUM	3	3	12600	4600	UG/KG
N-NITROSODIPHENYLAMINE	3	3	1300	630	UG/KG
NICKEL	3	3	24600	11800	UG/KG
NITRATE/NITRITE	6	6	6800	2500	UG/KG
OIL AND GREASE	3	3	6800000	4400000	UG/KG
PHENANTHRENE	1	1	190	190	UG/KG
PHENOL	1	1	650	650	UG/KG
POTASSIUM	2	2	3570000	1080000	UG/KG
PYRENE	2	2	310	100	UG/KG
SELENIUM	1	1	21300	21300	UG/KG
SILVER	3	3	49100	32100	UG/KG
SODIUM	3	3	289000	147000	UG/KG
STRONTIUM	4	4	179000	40600	UG/KG
THALLIUM	3	3	470	340	UG/KG
TIN	4	4	1080000	314000	UG/KG
TOLUENE	6	6	6	2	UG/KG
TRICHLOROETHENE	3	3	8	5	UG/KG
TRITIUM	3	3	380	233.8	PCI/L
URANIUM-233,-234	2	2	2.4	1.4	PCI/G
URANIUM-235	2	2	0.08	0.071	PCI/G
URANIUM-238	1	1	1.4	1.4	PCI/G
VANADIUM	3	3	58400	33400	UG/KG
ZINC	3	3	136000	87800	UG/KG

Table B-1 (continued)

OU1 - SURFICIAL SOILS

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
ACENAPHTHENE	1	1	230	230	UG/KG
ACENAPHTHYLENE	1	1	110	110	UG/KG
ANTHRACENE	1	1	220	220	UG/KG
ANTIMONY	1	1	9800	9800	UG/KG
ARSENIC	3	3	8500	5700	UG/KG
BENZO(a)ANTHRACENE	3	3	310	180	UG/KG
BENZO(a)PYRENE	4	4	390	300	UG/KG
BENZO(b)FLUORANTHENE	3	3	360	280	UG/KG
BENZO(ghi)PERYLENE	3	3	350	230	UG/KG
BENZO(k)FLUORANTHENE	4	4	410	230	UG/KG
BERYLLIUM	5	5	1200	1000	UG/KG
CADMIUM	4	4	950	860	UG/KG
CESIUM	3	3	4400	4100	UG/KG
CHRYSENE	4	4	400	120	UG/KG
COBALT	3	3	10100	9200	UG/KG
FLUORANTHENE	3	3	450	240	UG/KG
FLUORANTHENE	3	3	450	240	UG/KG
FLUORENE	1	1	140	140	UG/KG
INDENO(1,2,3-cd)PYRENE	3	3	250	210	UG/KG
LITHIUM	3	3	15000	14700	UG/KG
MERCURY	4	4	70	60	UG/KG
MOLYBDENUM	3	3	5100	4300	UG/KG
NAPHTHALENE	1	1	110	110	UG/KG
PHENANTHRENE	3	3	370	290	UG/KG
PYRENE	1	1	220	220	UG/KG
SELENIUM	4	4	440	390	UG/KG
SODIUM	3	3	362000	329000	UG/KG
STRONTIUM	3	3	49900	42900	UG/KG
THALLIUM	4	4	430	280	UG/KG
TIN	3	3	55300	39500	UG/KG

Table B-1 (continued)

OU1 - SURFACE WATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	4	4	4	1	UG/L
1,1-DICHLOROETHANE	3	3	4	4	UG/L
1,1-DICHLOROETHENE	2	2	1	1	UG/L
1,2,4-TRICHLOROBENZENE	1	1	4	4	UG/L
1,2-DICHLOROETHENE	3	3	44	27	UG/L
1,4-DICHLOROBENZENE	1	1	4	4	UG/L
2,4-DINITROTOLUENE	1	1	4	4	UG/L
2-BUTANONE	7	7	27	4	UG/L
2-HEXANONE	1	1	1	1	UG/L
4-CHLORO-3-METHYLPHENOL	1	1	1	1	UG/L
ACENAPHTHENE	1	1	5	5	UG/L
ACETONE	3	3	180	36	UG/L
ALUMINUM	3	3	263000	57600	UG/L
AMERICIUM-241	2	2	0.006	0.005	PCI/L
ANTIMONY	2	2	416	126	UG/L
ARSENIC	3	3	1030	116	UG/L
BARIUM	3	3	4490	4450	UG/L
BENZOIC ACID	1	1	8	8	UG/L
BERYLLIUM	3	3	17.3	13.1	UG/L
BICARBONATE	3	3	570000	290000	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	3	3	220	4	UG/L
CADMIUM	3	3	64.4	3.4	UG/L
CALCIUM	3	3	803000	160000	UG/L
CARBON DISULFIDE	6	6	5	2	UG/L
CARBON TETRACHLORIDE	4	4	46	3	UG/L
CARBONATE	1	1	5000	5000	UG/L
CESIUM	1	1	2530	2530	UG/L
CHLORIDE	4	4	79000	64000	UG/L
CHLOROFORM	4	4	8	4	UG/L
CHROMIUM	3	3	275	68.8	UG/L
COBALT	3	3	489	73	UG/L
COPPER	3	3	607	177	UG/L
DI-n-BUTYL PHTHALATE	1	1	1	1	UG/L
IRON	3	3	3220000	57100	UG/L
LEAD	3	3	516	233	UG/L
LITHIUM	3	3	180	172	UG/L
MAGNESIUM	3	3	31300	30500	UG/L
MANGANESE	3	3	27700	4060	UG/L
MERCURY	5	5	1.7	1.1	UG/L
METHYLENE CHLORIDE	3	3	38	34	UG/L
MOLYBDENUM	4	4	333	46.5	UG/L
N-NITROSO-DI-n-PROPYLAMINE	1	1	5	5	UG/L
N-NITROSODIPHENYLAMINE	4	4	16	9	UG/L
NICKEL	3	3	646	95	UG/L
NITRATE/NITRITE	3	3	7400	4600	UG/L
OIL AND GREASE	8	8	13000	1000	UG/L
PHENOL	2	2	1	1	UG/L
PLUTONIUM-239/240	3	3	0.007	0.004	PCI/L
POTASSIUM	4	4	13100	9880	UG/L
PYRENE	1	1	4	4	UG/L
SELENIUM	3	3	13.4	10.2	UG/L
SILVER	3	3	148	11.4	UG/L
SODIUM	3	3	69500	57200	UG/L
STRONTIUM	6	6	1460	417	UG/L
STRONTIUM-89,90	1	1	0.37	0.37	PCI/L
SULFATE	3	3	130000	70000	UG/L
TETRACHLOROETHENE	3	3	19	9	UG/L
THALLIUM	3	3	3.3	1.6	UG/L
TIN	4	4	1530	198	UG/L
TOLUENE	6	6	6	2	UG/L
TOTAL DISSOLVED SOLIDS	4	4	650000	460000	UG/L
TOTAL SUSPENDED SOLIDS	3	3	520000	80000	UG/L
TOTAL XYLENES	1	1	1	1	UG/L
TRICHLOROETHENE	4	4	47	14	UG/L
URANIUM-233,-234	3	3	3.9	2.3	PCI/L
URANIUM-235	3	3	0.32	0.097	PCI/L
URANIUM-238	3	3	3.1	1.2	PCI/L
VANADIUM	3	3	1650	364	UG/L
VINYL ACETATE	6	6	2	1	UG/L
VINYL CHLORIDE	2	2	9	9	UG/L
ZINC	3	3	2840	2300	UG/L

Table B-2 FY92 RFEDS Operable Unit 2 Analytical Data
OU2 - GROUNDWATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	3	3	63	9	UG/L
1,1-DICHLOROETHANE	3	3	59	4	UG/L
1,1-DICHLOROETHENE	3	3	32	13	UG/L
1,2-DICHLOROETHANE	3	3	2	2	UG/L
1,2-DICHLOROETHENE	3	3	37	1	UG/L
2-BUTANONE	3	3	10	7	UG/L
2-HEXANONE	2	2	8	5	UG/L
4-METHYL-2-PENTANONE	4	4	4	1	UG/L
ACETONE	3	3	180	37	UG/L
ALUMINUM	4	4	53100	52.6	UG/L
AMERICIUM-241	3	3	0.009656	0.004917	PCI/L
ANTIMONY	5	5	26.4	6	UG/L
ARSENIC	18	18	11.7	2	UG/L
BARIUM	4	4	351	208.1	UG/L
BENZENE	1	1	1	1	UG/L
BERYLLIUM	6	6	4	1	UG/L
BICARBONATE	3	3	599000	550000	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	3	3	11	7	UG/L
BROMODICHLOROMETHANE	1	1	1	1	UG/L
CADMIUM	7	7	4.8	0.4	UG/L
CALCIUM	4	4	127000	79220.3	UG/L
CARBON DISULFIDE	1	1	3	3	UG/L
CARBON TETRACHLORIDE	3	3	2500	1100	UG/L
CARBONATE	3	3	15200	6100	UG/L
CESIUM	3	3	50	40	UG/L
CESIUM-137	3	3	0.5168	-0.08	PCI/L
CHLORIDE	3	3	958000	599000	UG/L
CHLOROBENZENE	1	1	1	1	UG/L
CHLOROFORM	3	3	2500	540	UG/L
CHROMIUM	3	3	40.6	9	UG/L
COBALT	3	3	46.7	31.2	UG/L
COPPER	4	4	19.7	17.1	UG/L
CYANIDE	5	5	6.5	2	UG/L
Di-n-BUTYL PHTHALATE	4	4	4	2	UG/L
DIETHYL PHTHALATE	3	3	3	2	UG/L
GROSS BETA - DISSOLVED	3	3	2.73	1.007	PCI/L
IRON	4	4	248000	17.2	UG/L
LEAD	6	6	126	1	UG/L
LITHIUM	6	6	685	40	UG/L
MAGNESIUM	4	4	98900	27900	UG/L
MANGANESE	4	4	3580	16.4	UG/L
MERCURY	3	3	0.36	0.1	UG/L
METHYLENE CHLORIDE	5	5	1600	14	UG/L
MOLYBDENUM	3	3	66.5	34.8	UG/L
N-NITROSODIPHENYLAMINE	3	3	12	8	UG/L
NICKEL	4	4	220	89.7	UG/L
NITRATE/NITRITE	4	4	82800	8420	UG/L
PENTACHLOROPHENOL	1	1	4	4	UG/L
PLUTONIUM-239/240	3	3	0.009023	0.003913	PCI/L
POTASSIUM	4	4	26500	2500	UG/L
SELENIUM	13	13	65.2	2	UG/L
SILVER	2	2	3.5	2	UG/L
SODIUM	4	4	214000	41574.5	UG/L
STRONTIUM	4	4	2800	1360	UG/L
STRONTIUM-89/90	3	3	0.3505	0.1336	PCI/L
SULFATE	3	3	1084000	1076000	UG/L
TETRACHLOROETHENE	3	3	2500	440	UG/L
THALLIUM	3	3	3.1	2	UG/L
TIN	3	3	164	76.3	UG/L
TOLUENE	3	3	10	7	UG/L
TOTAL DISSOLVED SOLIDS	3	3	2845000	2425000	UG/L
TOTAL SUSPENDED SOLIDS	2	2	210000	100000	UG/L
TOTAL XYLENES	2	2	2	2	UG/L
TRICHLOROETHENE	3	3	190	110	UG/L
TRITIUM	3	3	344.2	273.7	PCI/L
URANIUM-235	3	3	0.3842	0.151	PCI/L
VANADIUM	3	3	96.1	45.7	UG/L
VINYL ACETATE	1	1	5	5	UG/L
VINYL CHLORIDE	1	1	520	520	UG/L
ZINC	4	4	768	37.2	UG/L
pH	3	3	8.4	7.5	PH

Table B-2 (continued)

OU2 - SOIL BORINGS

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	3	3	290	97	UG/KG
1,1,2,2-TETRACHLOROETHANE	1	1	3	3	UG/KG
1,1-DICHLOROETHENE	2	2	3	1	UG/KG
1,2-DICHLOROETHENE	4	4	5	2	UG/KG
1,4-DICHLOROBENZENE	1	1	43	43	UG/KG
2-BUTANONE	5	5	10	8	UG/KG
2-METHYLNAPHTHALENE	1	1	160	160	UG/KG
4-METHYL-2-PENTANONE	1	1	2	2	UG/KG
ACENAPHTHENE	1	1	58	58	UG/KG
ACETONE	3	3	280	96	UG/KG
ANTIMONY	3	3	10500	8700	UG/KG
AROCOR-1254	1	1	21	21	UG/KG
ARSENIC	4	4	10000	8200	UG/KG
BARIUM	5	5	46400	30.7	UG/KG
BENZO(a)PYRENE	3	3	350	250	UG/KG
BERYLLIUM	10	10	1200	0.5	UG/KG
BIS(2-ETHYLHEXYL)PHTHALATE	3	3	18000	2600	UG/KG
CADMIUM	3	3	1000	810	UG/KG
CALCIUM	1	1	667000	667000	UG/KG
CARBON TETRACHLORIDE	3	3	30	6	UG/KG
CESIUM	3	3	5800	5400	UG/KG
CHLOROFORM	3	3	19	6	UG/KG
CHRYSENE	1	1	210	210	UG/KG
COBALT	3	3	11500	9800	UG/KG
COPPER	4	4	5600	4100	UG/KG
DI-n-BUTYL PHTHALATE	3	3	690	170	UG/KG
DI-n-OCTYL PHTHALATE	3	3	160	60	UG/KG
DIETHYL PHTHALATE	1	1	82	82	UG/KG
ETHYLBENZENE	4	4	4	2	UG/KG
FLUORANTHENE	3	3	160	37	UG/KG
LITHIUM	3	3	22900	16700	UG/KG
MAGNESIUM	4	4	969000	964	UG/KG
MERCURY	8	8	120	100	UG/KG
METHYLENE CHLORIDE	3	3	210	140	UG/KG
MOLYBDENUM	4	4	7400	4000	UG/KG
N-NITROSODIPHENYLAMINE	3	3	89	49	UG/KG
NICKEL	3	3	9600	9300	UG/KG
NITRATE/NITRITE	3	3	4300	2600	UG/KG
PHENANTHRENE	3	3	300	94	UG/KG
POTASSIUM	6	6	8990000	500	UG/KG
PYRENE	3	3	120	49	UG/KG
SELENIUM	3	3	2100	360	UG/KG
SILICON	3	3	16400	4700	UG/KG
SILVER	5	5	1100	990	UG/KG
SODIUM	6	6	1090000	290	UG/KG
STRONTIUM	6	6	62600	7.7	UG/KG
SULFIDE	8	8	5000	2000	UG/KG
TETRACHLOROETHENE	6	6	15	4	UG/KG
THALLIUM	3	3	910	560	UG/KG
TIN	3	3	44100	42300	UG/KG
TOLUENE	7	7	480	5	UG/KG
TOTAL XYLENES	3	3	18	5	UG/KG
TRICHLOROETHENE	3	3	5	3	UG/KG
VANADIUM	2	2	10900	4400	UG/KG

Table B-2 (continued)

OU2 - SEDIMENT

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
ACETONE	3	3	33	17	UG/KG
ALUMINUM	1	1	6920000	6920000	UG/KG
AROCLOP-1254	1	1	78	78	UG/KG
ARSENIC	1	1	4500	4500	UG/KG
BARIUM	1	1	95300	95300	UG/KG
BERYLLIUM	1	1	2500	2500	UG/KG
BIS(2-ETHYLHEXYL)PHTHALATE	3	3	310	180	UG/KG
CALCIUM	1	1	27400000	27400000	UG/KG
CHROMIUM	1	1	7900	7900	UG/KG
COPPER	1	1	13200	13200	UG/KG
DI-n-BUTYL PHTHALATE	3	3	90	50	UG/KG
FLUORANTHENE	2	2	61	50	UG/KG
IRON	1	1	8980000	8980000	UG/KG
LEAD	1	1	12200	12200	UG/KG
LITHIUM	1	1	7200	7200	UG/KG
MAGNESIUM	1	1	1980000	1980000	UG/KG
METHYLENE CHLORIDE	4	4	3000	15	UG/KG
N-NITROSODIPHENYLAMINE	3	3	370	180	UG/KG
NITRATE/NITRITE	2	2	1600	1600	UG/KG
OIL AND GREASE	1	1	1600000	1600000	UG/KG
PYRENE	2	2	95	50	UG/KG
SILVER	1	1	15000	15000	UG/KG
STRONTIUM	1	1	62400	62400	UG/KG
TETRACHLOROETHENE	1	1	7	7	UG/KG
TIN	1	1	404000	404000	UG/KG
TRITIUM	2	2	157.5	112.1	PCI/L
URANIUM-233, -234	1	1	1.3	1.3	PCI/G
URANIUM-235	1	1	0.03	0.03	PCI/G
URANIUM-238	1	1	0.94	0.94	PCI/G
VANADIUM	1	1	22300	22300	UG/KG
ZINC	1	1	735000	735000	UG/KG

Table B-2 (continued)

OU2 - SURFICIAL SOILS

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
URANIUM-233,-234	3	3	3.4	2.3	PCI/G
URANIUM-235	4	4	0.22	0.16	PCI/G
URANIUM-238	3	3	2.1	1.5	PCI/G

Table B-2 (continued)

OU2 - SURFACE WATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	4	4	4	1	UG/L
1,1,2,2-TETRACHLOROETHANE	1	1	2	2	UG/L
1,1-DICHLOROETHANE	3	3	7	5	UG/L
1,1-DICHLOROETHENE	3	3	9	5	UG/L
1,2-DICHLOROETHENE	5	5	4	1	UG/L
2-HEXANONE	1	1	1	1	UG/L
4-METHYL-2-PENTANONE	1	1	1	1	UG/L
ACETONE	5	5	26	13	UG/L
ALUMINUM	3	3	78700	22800	UG/L
AMERICIUM-241	3	3	0.006	0.005	PCI/L
ANTIMONY	3	3	61.1	23.9	UG/L
ARSENIC	3	3	31.1	6.9	UG/L
BARIUM	3	3	831	331	UG/L
BENZENE	1	1	1	1	UG/L
BERYLLIUM	3	3	25.1	3.8	UG/L
BICARBONATE	3	3	300000	130000	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	12	12	3	1	UG/L
BUTYL BENZYL PHTHALATE	1	1	1	1	UG/L
CADMIUM	4	4	4.9	2.4	UG/L
CALCIUM	3	3	486000	258000	UG/L
CARBON DISULFIDE	1	1	6	6	UG/L
CARBON TETRACHLORIDE	4	4	4	2	UG/L
CHLORIDE	3	3	39000	12000	UG/L
CHLOROBENZENE	1	1	1	1	UG/L
CHLOROETHANE	1	1	2	2	UG/L
CHLOROFORM	6	6	4	2	UG/L
CHROMIUM	3	3	85.5	23.2	UG/L
COBALT	3	3	41.5	3.3	UG/L
COPPER	3	3	70.2	47.6	UG/L
DI-n-BUTYL PHTHALATE	2	2	1	1	UG/L
IRON	3	3	70900	17000	UG/L
LEAD	3	3	116	43.7	UG/L
LITHIUM	3	3	152	59.2	UG/L
MAGNESIUM	3	3	53600	29100	UG/L
MANGANESE	3	3	3180	1370	UG/L
MERCURY	4	4	0.9	0.63	UG/L
METHYLENE CHLORIDE	5	5	25	9	UG/L
MOLYBDENUM	3	3	59.3	18.5	UG/L
N-NITROSODIPHENYLAMINE	3	3	11	1	UG/L
NICKEL	3	3	84	39.3	UG/L
NITRATE/NITRITE	6	6	5100	2300	UG/L
OIL AND GREASE	1	1	1000	1000	UG/L
PLUTONIUM-239/240	1	1	0.003	0.003	PCI/L
POTASSIUM	3	3	15300	4680	UG/L
SELENIUM	3	3	16	11.8	UG/L
SILVER	1	1	4.1	4.1	UG/L
SODIUM	3	3	106000	54100	UG/L
STRONTIUM	5	5	1200	550	UG/L
STRONTIUM-89,90	3	3	0.61	0.35	PCI/L
SULFATE	3	3	53000	16000	UG/L
TETRACHLOROETHENE	11	11	3	1	UG/L
TOLUENE	4	4	2	1	UG/L
TOTAL DISSOLVED SOLIDS	3	3	440000	150000	UG/L
TOTAL SUSPENDED SOLIDS	1	1	860000	860000	UG/L
TRICHLOROETHENE	3	3	12	3	UG/L
URANIUM-233,-234	3	3	5.7	2.9	PCI/L
URANIUM-235	3	3	0.35	0.22	PCI/L
URANIUM-238	1	1	2.9	2.9	PCI/L
VANADIUM	3	3	178	90.6	UG/L
VINYL CHLORIDE	5	5	9	3	UG/L
ZINC	3	3	1080	573	UG/L
beta-BHC	1	1	0.05	0.05	UG/L
pH	1	1	7.4	7.4	PH

Table B-2 (continued)

OU2 - DITCH/PIT

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
AMERICIUM-241	2	2	0.01205	0.008224	PCI/G
URANIUM-235	3	3	0.1755	0.0908	PCI/G

Table B-3 FY92 RFEDS Operable Unit 3 Analytical Data

OU3 - GROUNDWATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	1	1	2	2	UG/L
1,2-DICHLOROETHENE	1	1	3	3	UG/L
2-BUTANONE	1	1	3	3	UG/L
ACETONE	3	3	30	18	UG/L
ALUMINUM	3	3	1430	403	UG/L
ANTIMONY	3	3	32.7	11.3	UG/L
ARSENIC	3	3	6.4	3.2	UG/L
BARIUM	5	5	191	118.9	UG/L
BICARBONATE	3	3	246000	210000	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	1	1	3	3	UG/L
CADMIUM	4	4	2.3	0.3	UG/L
CALCIUM	5	5	94807.5	54700	UG/L
CARBON DISULFIDE	3	3	3	2	UG/L
CESIUM-137	3	3	0.9584	-0.283	PCI/L
CHLORIDE	3	3	52900	46000	UG/L
CHLOROFORM	4	4	26	3	UG/L
CHROMIUM	3	3	8.5	4.2	UG/L
COBALT	3	3	21	7.6	UG/L
COPPER	3	3	22.3	11.2	UG/L
IRON	5	5	48100	12.8	UG/L
LEAD	3	3	2.8	1.7	UG/L
LITHIUM	4	4	44	11.4	UG/L
MAGNESIUM	5	5	27377.3	13800	UG/L
MANGANESE	4	4	786.8	106	UG/L
METHYLENE CHLORIDE	5	5	8	6	UG/L
MOLYBDENUM	4	4	13.5	6.8	UG/L
NICKEL	4	4	53.3	25	UG/L
NITRATE/NITRITE	3	3	510	80	UG/L
POTASSIUM	5	5	5100	2000	UG/L
SELENIUM	4	4	43.1	6.8	UG/L
SILVER	1	1	2.1	2.1	UG/L
SODIUM	5	5	127000	45559.5	UG/L
STRONTIUM	6	6	754.2	187	UG/L
STRONTIUM-89,90	3	3	0.3856	0.3175	PCI/L
SULFATE	3	3	148000	99000	UG/L
TETRACHLOROETHENE	1	1	1	1	UG/L
TIN	3	3	25.2	12.6	UG/L
TOLUENE	4	4	4	4	UG/L
TOTAL DISSOLVED SOLIDS	3	3	550000	475000	UG/L
TOTAL SUSPENDED SOLIDS	1	1	110000	110000	UG/L
TRITIUM	3	3	249.6	192.8	PCI/L
VANADIUM	3	3	30.3	10.8	UG/L
ZINC	4	4	160	23	UG/L

Table B-3 (continued)

OU3 - SOIL BORINGS

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
ALUMINUM	3	3	18500000	11800000	UG/KG
ANTIMONY	1	1	8200	8200	UG/KG
ARSENIC	3	3	25930	10422	UG/KG
BARIUM	3	3	212000	124000	UG/KG
BERYLLIUM	3	3	4200	2800	UG/KG
CADMIUM	1	1	1100	1100	UG/KG
CALCIUM	3	3	8890000	7040000	UG/KG
CESIUM	3	3	3120	2650	UG/KG
CHROMIUM	3	3	30600	25400	UG/KG
COBALT	3	3	15900	13400	UG/KG
COPPER	3	3	31600	21600	UG/KG
IRON	3	3	20700000	13200000	UG/KG
LEAD	3	3	28200	18500	UG/KG
LITHIUM	3	3	19800	14400	UG/KG
MAGNESIUM	3	3	4390000	2320000	UG/KG
MANGANESE	3	3	427000	294000	UG/KG
MERCURY	4	4	350	190	UG/KG
MOLYBDENUM	4	4	10000	9600	UG/KG
NICKEL	3	3	40300	37700	UG/KG
NITRATE/NITRITE	4	4	1500	1400	UG/KG
PLUTONIUM-239/240	3	3	0.006	0.002	PCI/G
POTASSIUM	3	3	2570000	1330000	UG/KG
SILVER	3	3	2900	1300	UG/KG
SODIUM	3	3	444000	342000	UG/KG
STRONTIUM	3	3	113000	58500	UG/KG
SULFIDE	1	1	2000	2000	UG/KG
THALLIUM	3	3	870	537	UG/KG
VANADIUM	3	3	43400	32100	UG/KG
ZINC	3	3	99500	67100	UG/KG

Table B-3 (continued)

OU3 - SEDIMENT

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
BIS(2-ETHYLHEXYL)PHTHALATE	1	1	190	190	UG/KG
DI-n-BUTYL PHTHALATE	1	1	390	390	UG/KG
N-NITROSODIPHENYLAMINE	1	1	1100	1100	UG/KG

Table B-4 FY92 RFEDS Operable Unit 8 Analytical Data

OU8 - GROUNDWATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	6	6	9	3	UG/L
1,1-DICHLOROETHANE	3	3	12	3	UG/L
1,1-DICHLOROETHENE	5	5	6	3	UG/L
1,2-DICHLOROETHANE	2	2	6	3	UG/L
1,2-DICHLOROETHENE	3	3	170	3	UG/L
1,2-DICHLOROPROPANE	2	2	1	1	UG/L
ACETONE	3	3	36	28	UG/L
ALUMINUM	3	3	8800	3900	UG/L
ANTIMONY	3	3	18.7	5	UG/L
ARSENIC	8	8	5.1	2	UG/L
BARIUM	5	5	383	169.4	UG/L
BENZENE	1	1	2	2	UG/L
BERYLLIUM	6	6	1.5	1	UG/L
BICARBONATE	3	3	750000	578000	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	2	2	8	3	UG/L
BROMOMETHANE	2	2	7	3	UG/L
CADMIUM	9	9	4.8	0.3	UG/L
CALCIUM	5	5	284000	95197	UG/L
CARBON TETRACHLORIDE	5	5	560	1	UG/L
CARBONATE	1	1	24000	24000	UG/L
CESIUM	4	4	60	40	UG/L
CHLORIDE	3	3	520000	241000	UG/L
CHLOROBENZENE	3	3	4	3	UG/L
CHLOROFORM	3	3	100	8	UG/L
CHLOROMETHANE	1	1	4	4	UG/L
CHROMIUM	3	3	11.6	6.5	UG/L
COBALT	3	3	13.3	6.4	UG/L
COPPER	5	5	28.1	10	UG/L
CYANIDE	3	3	4.5	1.5	UG/L
DI-n-BUTYL PHTHALATE	3	3	4	1	UG/L
GROSS ALPHA PARTICLE RADIOAC	1	1	4.9	4.9	PCI/L
IRON	6	6	12100	52.3	UG/L
LEAD	10	10	40.4	1	UG/L
LITHIUM	8	8	436	70	UG/L
MAGNESIUM	5	5	123000	8212.1	UG/L
MANGANESE	5	5	504	83.7	UG/L
MERCURY	1	1	0.21	0.21	UG/L
METHYLENE CHLORIDE	4	4	10	7	UG/L
MOLYBDENUM	3	3	120	27.4	UG/L
N-NITROSODIPHENYLAMINE	2	2	10	5	UG/L
NICKEL	3	3	29.6	24.1	UG/L
NITRATE/NITRITE	4	4	2400000	1400000	UG/L
POTASSIUM	5	5	239000	7200	UG/L
SELENIUM	12	12	31.8	3	UG/L
SILVER	4	4	2.9	2.1	UG/L
SODIUM	5	5	761000	35068	UG/L
STRONTIUM	5	5	3020	473.1	UG/L
STRONTIUM-89,90	2	2	0.2819	0.2457	PCI/L
SULFATE	3	3	1190000	630000	UG/L
TETRACHLOROETHENE	3	3	110	37	UG/L
TIN	3	3	126	106	UG/L
TOLUENE	19	19	5	3	UG/L
TOTAL DISSOLVED SOLIDS	3	3	19000000	9750000	UG/L
TOTAL SUSPENDED SOLIDS	3	3	850000	12000	UG/L
TRICHLOROETHENE	3	3	510	25	UG/L
TRITIUM	3	3	397	233.7	PCI/L
VANADIUM	3	3	23.9	22.4	UG/L
VINYL ACETATE	1	1	1	1	UG/L
VINYL CHLORIDE	3	3	23	3	UG/L
ZINC	5	5	844	48.7	UG/L
pH	3	3	8	7.7	PH

Table B-4 (continued)

OU8 - SOIL BORINGS

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,1-TRICHLOROETHANE	3	3	11	4	UG/KG
1,1-DICHLOROETHANE	2	2	4	2	UG/KG
1,1-DICHLOROETHENE	1	1	2	2	UG/KG
1,2-DICHLOROETHANE	2	2	5	2	UG/KG
1,2-DICHLOROETHENE	1	1	2	2	UG/KG
2-BUTANONE	4	4	1000	56	UG/KG
4-METHYL-2-PENTANONE	1	1	2	2	UG/KG
ACETONE	7	7	18000	890	UG/KG
ALUMINUM	3	3	32700000	18200000	UG/KG
ANTIMONY	1	1	4100	4100	UG/KG
ARSENIC	5	5	24600	2500	UG/KG
BARIUM	3	3	11600000	530000	UG/KG
BENZENE	5	5	4	2	UG/KG
BERYLLIUM	6	6	8700	1400	UG/KG
BIS(2-ETHYLHEXYL)PHTHALATE	3	3	1100	880	UG/KG
BUTYL BENZYL PHTHALATE	1	1	69	69	UG/KG
CADMIUM	3	3	60400	550	UG/KG
CALCIUM	3	3	105000000	80800000	UG/KG
CARBON DISULFIDE	4	4	4	2	UG/KG
CARBON TETRACHLORIDE	2	2	2	1	UG/KG
CESIUM	3	3	2410000	1870000	UG/KG
CHLOROBENZENE	1	1	1	1	UG/KG
CHLOROFORM	3	3	1000	1000	UG/KG
CHROMIUM	6	6	81200	3200	UG/KG
COBALT	3	3	88900	17800	UG/KG
COPPER	6	6	73600	5300	UG/KG
DI-n-BUTYL PHTHALATE	3	3	50	47	UG/KG
ETHYLBENZENE	3	3	2	1	UG/KG
IRON	3	3	123000000	32300000	UG/KG
LEAD	3	3	31100	30300	UG/KG
LITHIUM	3	3	35800	15500	UG/KG
MAGNESIUM	3	3	6460000	4650000	UG/KG
MANGANESE	6	6	1620000	16200	UG/KG
MERCURY	3	3	1100	440	UG/KG
METHYLENE CHLORIDE	11	11	7000	540	UG/KG
MOLYBDENUM	4	4	37000	9000	UG/KG
N-NITROSODIPHENYLAMINE	1	1	42	42	UG/KG
NICKEL	5	5	133000	8700	UG/KG
NITRATE/NITRITE	6	6	1400000	630000	UG/KG
POTASSIUM	4	4	4620000	2360000	UG/KG
SELENIUM	3	3	2300	870	UG/KG
SILVER	4	4	5800	3700	UG/KG
SODIUM	3	3	3450000	1510000	UG/KG
STRONTIUM	6	6	354000	27400	UG/KG
STYRENE	5	5	6000	3000	UG/KG
SULFIDE	7	7	5000	2000	UG/KG
TETRACHLOROETHENE	3	3	22	6	UG/KG
TIN	6	6	84200	25400	UG/KG
TOLUENE	4	4	1000	6	UG/KG
TOTAL XYLENES	3	3	40	6	UG/KG
TRICHLOROETHENE	6	6	9	2	UG/KG
VANADIUM	5	5	110000	21200	UG/KG
ZINC	3	3	487000	108000	UG/KG

Table B-4 (continued)

OU8 - SURFACE WATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,2-DICHLOROETHENE	1	1	2	2	UG/L
2-BUTANONE	2	2	4	2	UG/L
4,4'-DDT	1	1	0.061	0.061	UG/L
ACETONE	5	5	27	12	UG/L
ALUMINIUM	3	3	64100	24100	UG/L
AMERICIUM-241	2	2	0.008	0.007	PCI/L
ANTHRACENE	1	1	2	2	UG/L
ANTIMONY	3	3	78.9	59.1	UG/L
ARSENIC	3	3	27.2	4.7	UG/L
BARIUM	3	3	2020	1500	UG/L
BENZENE	1	1	1	1	UG/L
BENZO(a)ANTHRACENE	1	1	1	1	UG/L
BERYLLIUM	3	3	57.4	20.9	UG/L
BICARBONATE	3	3	940000	310000	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	7	7	2	1	UG/L
BROMODICHLOROMETHANE	3	3	4	2	UG/L
BUTYL BENZYL PHTHALATE	1	1	2	2	UG/L
CADMIUM	3	3	117	72.4	UG/L
CALCIUM	4	4	1490000	59400	UG/L
CARBON DISULFIDE	1	1	4	4	UG/L
CARBON TETRACHLORIDE	3	3	100	37	UG/L
CARBONATE	1	1	5000	5000	UG/L
CESIUM	3	3	1500	0.3	UG/L
CHLORIDE	3	3	530000	130000	UG/L
CHLOROFORM	6	6	6	3	UG/L
CHROMIUM	3	3	240	95.9	UG/L
CHRYSENE	1	1	1	1	UG/L
COBALT	3	3	132	72.9	UG/L
COPPER	3	3	332	161	UG/L
DI-n-BUTYL PHTHALATE	7	7	4	1	UG/L
DI-n-OCTYL PHTHALATE	1	1	2	2	UG/L
FLUORANTHENE	1	1	2	2	UG/L
IRON	3	3	253000	47300	UG/L
ISOPHORONE	1	1	1	1	UG/L
LEAD	3	3	215	37.2	UG/L
LITHIUM	6	6	6380	1340	UG/L
MAGNESIUM	3	3	266000	225000	UG/L
MANGANESE	3	3	32100	2930	UG/L
MERCURY	3	3	2.4	1.8	UG/L
METHYLENE CHLORIDE	4	4	21	13	UG/L
MOLYBDENUM	3	3	174	24.6	UG/L
N-NITROSODIPHENYLAMINE	2	2	6	1	UG/L
NICKEL	3	3	284	87.3	UG/L
NITRATE/NITRITE	3	3	3400000	700000	UG/L
OIL AND GREASE	4	4	12000	1000	UG/L
PLUTONIUM-239/240	1	1	0.007	0.007	PCI/L
POTASSIUM	3	3	3330000	2240000	UG/L
PYRENE	1	1	2	2	UG/L
SELENIUM	3	3	27	14	UG/L
SILVER	2	2	16.7	11.7	UG/L
SODIUM	3	3	7560000	3980000	UG/L
STRONTIUM	6	6	7240	4220	UG/L
SULFATE	3	3	680000	180000	UG/L
TETRACHLOROETHENE	3	3	2	1	UG/L
THALLIUM	4	4	2.4	1.7	UG/L
TIN	6	6	294	166	UG/L
TOLUENE	3	3	9	2	UG/L
TOTAL DISSOLVED SOLIDS	3	3	25000000	5600000	UG/L
TOTAL SUSPENDED SOLIDS	4	4	290000	20000	UG/L
TRICHLOROETHENE	6	6	6	2	UG/L
TRITIUM	1	1	380	380	PCI/L
VANADIUM	3	3	677	88.8	UG/L
ZINC	3	3	4470	3890	UG/L

Table B-5 FY92 RFEDS Operable Unit 13 Analytical Data

OU13 - GROUNDWATER

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
ACETONE	1	1	2	2	UG/L
CALCIUM	1	1	34900	34900	UG/L
MAGNESIUM	1	1	8040	8040	UG/L
MANGANESE	1	1	89.6	89.6	UG/L
SODIUM	1	1	18600	18600	UG/L

Table B-5 (continued)

OU13 - SOIL BORINGS

CHEMICAL/RADIONUCLIDE	# DATA	# DETECTS	MAXIMUM RESULT	MINIMUM RESULT	UNITS
1,1,2-TRICHLOROETHANE	1	1	6	6	UG/KG
1,1-DICHLOROETHENE	1	1	2	2	UG/KG
2-BUTANONE	3	3	9	6	UG/KG
2-HEXANONE	1	1	1	1	UG/KG
4-METHYL-2-PENTANONE	1	1	2	2	UG/KG
ACETONE	4	4	710	220	UG/KG
ALUMINUM	3	3	34500000	12000000	UG/KG
ARSENIC	3	3	10200	7400	UG/KG
BARIUM	3	3	165000	125000	UG/KG
BENZENE	2	2	4	2	UG/KG
BERYLLIUM	2	2	1100	860	UG/KG
CADMIUM	2	2	1200	1000	UG/KG
CALCIUM	3	3	27300000	17800000	UG/KG
CARBON DISULFIDE	11	11	5	2	UG/KG
CHLOROBENZENE	1	1	2	2	UG/KG
CHLOROFORM	4	4	4	3	UG/KG
CHROMIUM	3	3	33700	15300	UG/KG
COBALT	3	3	9900	9200	UG/KG
COPPER	3	3	36900	15700	UG/KG
ETHYLBENZENE	2	2	5	3	UG/KG
IRON	3	3	27800000	13900000	UG/KG
LEAD	3	3	47700	12500	UG/KG
LITHIUM	3	3	22600	7200	UG/KG
MAGNESIUM	3	3	4530000	2170000	UG/KG
MANGANESE	3	3	585000	461000	UG/KG
MERCURY	6	6	230	180	UG/KG
METHYLENE CHLORIDE	6	6	32	24	UG/KG
NICKEL	3	3	29800	15300	UG/KG
NITRATE/NITRITE	6	6	8700	1900	UG/KG
POTASSIUM	3	3	1920000	1200000	UG/KG
SODIUM	3	3	222000	102000	UG/KG
STRONTIUM	3	3	98000	50300	UG/KG
SULFIDE	12	12	6000	2000	UG/KG
TIN	3	3	31700	28700	UG/KG
TOLUENE	5	5	2	1	UG/KG
TRICHLOROETHENE	1	1	2	2	UG/KG
VANADIUM	3	3	63100	32700	UG/KG
ZINC	3	3	115000	61100	UG/KG

TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
GROUNDWATER QUALITY STANDARDS (ug/l)

					FEDERAL STANDARDS					STATE STANDARDS (TBCs)						
Parameter	Type (5)	PQL		Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goal TBCs (b)	RCRA Subpart F Limit (c)	CDH WQCC Groundwater Quality Standards (d)						
		RFP	CDH		Table A (d) (7)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Site-Specific (g)					
											Table 6 Radionuclides Women Creek	Table 6 Radionuclides Wainu Creek				
Bicarbonate	A	10,000		E310.1												
Carbonate	A	10,000		E310.1												
Chloride	A	5,000		E325	250,000 *							250,000				
Chlorine	A	1,000		E4500												
Fluoride	A	5,000		E340	4,000; 2,000*		4,000				4,000		2,000			
N as Nitrate	A	5,000		E353.1	10,000			10,000			10,000					
N as Nitrate+Nitrite	A	5,000		E353.1		10,000		10,000					100,000			
N as Nitrite	A	5,000		E354.1		1,000		1,000			1,000		10,000			
Sulfate	A	5,000		E375.4	250,000*							250,000				
Sulfide	A															
Coliform (total)	B	1		SM9221C	1/100 ml						1/100 ml					
Ammonia as N	C	5,000		E350												
Dioxin	D		0.01 (9)	d	3.0E-11 (h)		0.0 (h)			0.00000022					1.3E-08	
Sulfur	E	100,000		E800												
Dissolved Oxygen	FP	500		SM4500												
pH	FP	0.1		E150.1	6.5-8.5 *							6.5-8.5	6.5-8.5			
Specific Conductance	FP	1		E120.1												
Temperature	FP															
Boron	I	5,000		E8010									750			
Total Dissolved Solids	I	10,000		E160.1	500,000*									400,000 (1)		
Aluminum	M	200		CT		50 to 200*										
Antimony	M	60		CT	6.0 (h)		6.0 (h)						5,000			
Arsenic	M	10		CT	50				50		50		100			
Arsenic III	M															
Arsenic V	M															
Barium	M	200		CT	2,000 (e)			2,000 (e)	1,000		1,000					

TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
GROUNDWATER QUALITY STANDARDS (ug/l)

					FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
Parameter	Type (5)	PQL		Method (6)	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goal TBCs (b)	RCRA Subpart F Limit (c)	CDN WQCC Groundwater Quality Standards (d)							
		RFP	CDH		(e)	(b)	(a)	(b)	(c)	Statewide	Site-Specific (g)						
										Table A (d) (7)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Women Creek	Table 6 Radionuclides Walnut Creek
2,4,5-TP Silvex	P		0.5	d	10	50		50	10	50							
2,4-Dichlorophenoxyacetic Acid (2,4-D)	P		1	d	100	70		70	100	70							
Acrolein	P		10														
Aldicarb	P		10			3 (l)		1 (l)		10							
Aldicarb Sulfone	P				2.0 (l)		1.0 (l)										
Aldicarb Sulfoxide	P				4.0 (l)		1.0 (l)										
Aldrin	P	0.05	0.1	CP						0.002					0.000074		
Bromacil	P																
Carbofuran	P			d		40		40		36							
Chloranil	P																
Chlordane (Alpha)	P	0.5	1	CP		2		0		0.03					0.00046		
Chlordane (Gamma)	P	0.5	1	CP		2		0		0.03					0.00046		
Chlorpyrifos	P			E819													
DDT	P	0.1	0.1	CP						0.1					0.000024		
DDT Metabolite (DDD)	P	0.1		CP													
DDT Metabolite (DDE)	P	0.1	0.1	CP						0.1							
Dalapon	P				200 (h)		200 (h)										
Demeton	P																
Diazinon	P																
Dieldrin	P	0.1	0.1	CP						0.002					0.000071		
Dinoseb	P				7.0 (h)		7.0 (h)										
Diquat	P				20.0 (h)		20.0 (h)										
Endosulfan I	P	0.05		CP													
Endosulfan II	P	0.1		CP													
Endosulfan sulfate	P	0.1		CP													
Endothall	P				100.0 (h)		100.0 (h)										
Endrin	P	0.1	0.1	CP	2.0 (h)		2.0 (h)		0.2	0.2							
Endrin Aldehyde	P		0.1							0.2							
Endrin Ketone	P	0.1		CP													

TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
GROUNDWATER QUALITY STANDARDS (ug/l)

					FEDERAL STANDARDS					STATE STANDARDS (TBCs)						
Parameter	Type (5)	PQL MDL		Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goal TBCs (b)	RCRA Subpart F Limit (c)	CDH WQCC Groundwater Quality Standards (d)						
		RFP	CDH		Table A (d) (7)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6					
											Radionuclides Women Creek	Radionuclides Walnut Creek				
Guthion	P															
Glyphosate	P				700.0 (h)		700.0 (h)									
Heptachlor	P	0.05	0.05	CP		0.4		0		0.008					0.00028	
Heptachlor Epoxide	P	0.05	0.05	CP		0.2		0		0.09						
Hexachlorocyclohexane, Alpha	P	0.05	0.05	CP						0.008					0.0092	
Hexachlorocyclohexane, Beta	P	0.05	0.1 (g)	CP											0.0183	
Hexachlorocyclohexane, BHC	P		0.05													
Hexachlorocyclohexane, Delta	P	0.05		CP												
Hexachlorocyclohexane, Tech	P		0.5 (g)	I											0.0123	
Hexachlorocyclohexane, Lindane	P	0.05	0.05	CP	4	0.2		0.2	4.0	0.2					0.0188	
Malathion	P															
Methoxychlor	P	0.5	0.5	CP	100	40		40	100	40	100					
Mirex	P															
Oxamyl (Vydate)	P				200.0 (h)		200.0 (h)									
Parathion	P															
Picloram	P				500.0 (h)		500.0 (h)									
PCBs	P	0.5	1	CP		0.5		0		0.005					0.000079	
Simazine	P			e	4 (h)		4 (h)								4	
Toxaphene	P	1	5	CP		3		0	5.0	0.03	5					
Vaponite 2	P															
Aroclor 1016	PP	0.5		CP												
Aroclor 1221	PP	0.5		CP												
Aroclor 1232	PP	0.5		CP												
Aroclor 1242	PP	0.5		CP												
Aroclor 1248	PP	0.5		CP												
Aroclor 1254	PP	1		CP												
Aroclor 1260	PP	1		CP												
Atrazine	PP		1 (g)	e		3		3							3	

**TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
GROUNDWATER QUALITY STANDARDS (ug/l)**

					FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
Parameter	Type (5)	PQL MDL		Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goal TBCs (b)	RCRA Subpart F Limit (c)	CDH WQCC Groundwater Quality Standards (d)							
		RFP	CDH		Table A (d) (7)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides						
											Women Creek	Walnut Creek					
Americium (pCi/l)	R															0.05	0.05
Americium 241 (pCi/l)	R	0.01															
Cesium 134 (pCi/l)	R	1								80 (2)						80	80
Cesium 137 (pCi/l)	R	1															
Gross Alpha (pCi/l)	R	2			15 (8)						15(8)					7	11
Gross Beta (pCi/l)	R	4			50 (4 mrem/yr)						4 mrem/yr					5	19
Plutonium (pCi/l)	R															0.05	0.05
Plutonium 238+239+240 (pCi/l)	R	0.01								15 (2)							
Radium 226+228 (pCi/l)	R	0.5/1.0 (4)			5					5 (2)							
Strontium 89+90 (pCi/l)	R	1															
Strontium 90 (pCi/l)	R				8 (3)					8 (2)						8	8
Thorium 230+232 (pCi/l)	R									80 (2)							
Tritium (pCi/l)	R				20,000 (3)					20,000 (2)						500	500
Uranium 233+234 (pCi/l)	R																
Uranium 235 (pCi/l)	R	0.6															
Uranium 238 (pCi/l)	R	0.6															
Uranium (Total) (pCi/l)	R															5	10
1,2,4,5-Tetrachlorobenzene	SV		10	b						2							
1,2,4-Trichlorobenzene	SV	10		CS	70 (h)			70 (h)									
1,2-Dichlorobenzene (Ortho)	SV	10	1	CS		800		800		820							
1,2-Diphenylhydrazine	SV			b						0.05							
1,3-Dichlorobenzene (Meta)	SV	10	1	CS						820							
1,4-Dichlorobenzene (Para)	SV	10	1	CS	75		75			75							
2,4,5-Trichlorophenol	SV	50		CS						700							
2,4,6-Trichlorophenol	SV	10	50	CS						2					1.2		
2,4-Dichlorophenol	SV	10	50	CS						21							
2,4-Dimethylphenol	SV	10		CS													
2,4-Dinitrophenol	SV	50	50	CS						14							

**TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSB₀/TBCs (September 30, 1992) +
GROUNDWATER QUALITY STANDARDS (ug/l)**

[illegible]

TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
GROUNDWATER QUALITY STANDARDS (ug/l)

Parameter	Type (5)	PQL		Method (6)	FEDERAL STANDARDS					STATE STANDARDS (TBCs)						
		MDL			SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goal TBCs (b)	RCRA Subpart F Limit (c)	CDH WQCC Groundwater Quality Standards (d)						
										Statewide Table A (d) (7)	Site-Specific (g)					
											Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Women Creek Walnut Creek
		RFP	CDH													
bis(2-Chloroethyl)ether	SV	10		CS						0.03					0.0000037	
bis(2-Chloroisopropyl)ether	SV	10		CS												
bis(2-Ethylhexyl)phthalate	SV	10		CS												
Butadiene	SV															
Butylbenzylphthalate	SV	10		CS												
Chlorinated Ethers	SV															
Chlorinated Naphthalenes	SV															
Chloroalkylethers	SV	10		CS												
Chlorophenol	SV															
Chrysene	SV	10		CS												
Dibenzofuran	SV	10		CS												
Dibenz(a,h)anthracene	SV	10		CS												
Dichlorobenzenes	SV															
Dichlorobenzidine	SV	20	10 (g)	CS											0.01	
Diethylphthalate	SV	10		CS												
Di(2-ethylhexyl)adipate	SV				400 (h)			400 (h)								
Di(2-ethylhexyl)phthalate	SV				6.0 (h)			0.0 (h)								
Dimethylphthalate	SV	10		CS												
Di-n-butylphthalate	SV	10		CS												
Di-n-octylphthalate	SV	10		CS												
Ethylene Glycol	SV			d						7,000						
Fluoranthene	SV	10		CS												
Fluorene	SV	10		CS												
Formaldehyde	SV															
Haloethers	SV															
Hexachlorobenzene	SV	10	10	CS	1.0 (h)			0 (h)		6					0.00072	
Hexachlorobutadiene	SV	10	10	CS						1					0.45	
Hexachlorocyclopentadiene	SV	10		CS	50.0 (h)			50.0 (h)		49						
Hexachloroethane	SV	10		CS											1.9	
Hydrazine	SV															
Indeno(1,2,3-cd)pyrene	SV	10		CS												
Isophorone	SV	10	10	CS						1,050						

TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
GROUNDWATER QUALITY STANDARDS (ug/l)

FEDERAL STANDARDS										STATE STANDARDS (TBCs)										
Parameter	Type (d)	PQL		RFP	CDH (c)	Method (c)	SDWA		SDWA		SDWA		RCRA		CDH WQCC Groundwater Quality Standards (d)					
		MDL	Method				Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Subpart F Limit (c)	Table A (d) (7)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture TDS	Table 4 Chronic	Table 5 Radiocutides				
																	TBCs	TBCs	Goal	Goal
Naphthalene	SV	10				CS														
Nitrobenzene	SV	10				CS														
Nitrophenols	SV																			
Nitrosamines	SV																			
Nitrosodibutylamine	SV					b														
Nitrosodiphenylamine	SV					b														
Nitrosodimethylamine	SV					b														
Nitrosopyrrolidine	SV					b														
N-Nitrosodiphenylamine	SV	10				CSb														
N-Nitroso-di-n-propylamine	SV	10				CSb														
Pentachlorinated Ethanes	SV					b														
Pentachlorobenzene	SV					b														
Pentachlorophenol	SV	50				CS														
Phenanthrene	SV	10				CS														
Phenol	SV	10				CS														
Phthalate Esters	SV																			
Polynuclear Aromatic Hydrocarbons	SV																			
Vinyl Chloride	SV	10				1 (h)	2	0												
1,1,1-Trichloroethane	V	5				CV	200	200												
1,1,2,2-Tetrachloroethane	V	5				1 (h)	5.0 (h)	3.0 (h)												
1,1,2-Trichloroethane	V	5				CV	7	7												
1,1-Dichloroethane	V	5				CV	5	0												
1,2-Dichloroethane	V	5				CV	70	70												
1,2-Dichloroethane (cis)	V	5				a														
1,2-Dichloroethane (total)	V	5				CV	100	100												
1,2-Dichloroethane (trans)	V	5				CV	5	0												
1,2-Dichloropropane	V	5				CV														
1,3-Dichloropropane (cis)	V	5				CV														

TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS										STATE STANDARDS (TBCs)									
Parameter	Type (B)	PQL		Method (C)	SDWA		SDWA		SDWA		SDWA		SDWA		CDH WQCC Groundwater Quality Standards (G)								
		MDL	RFP		Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Table 1 Human Health	Table 2 Secondary Agriculture	Table 3 Drinking	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides					
																			CDH (G)	CDH (G)			
																					CDH (G)	CDH (G)	
1,3-Dichloropropene (trans)	V	5		CV																			
2-Butanone	V	10		CV																			
2-Hexanone	V	10		CV																			
4-Methyl-2-pentanone	V	10		CV																			
Acetone	V	10		CV																			
Acrylonitrile	V		15 (g)	c																			
Benzene	V	5		1 CV	5		0										1						
Bromodichloromethane	V	5		1 CV													0.3						
Bromofom	V	5		1 CV													4						
Bromomethane	V	10		CV																			
Carbon Disulfide	V	5		CV													0.3						
Carbon Tetrachloride	V	5		CV	5		0										100						
Chlorinated Benzenes	V	10		CV/CS		100																	
Chlorobenzene	V	5		1 CV/CS																			
Chloroethane	V	10		CV																			
Chloroform	V	5		1 CV	Tot THM <100**												6	0.19					
Chloromethane	V	10		CV													14						
Dibromochloromethane	V	5		1 CV																			
Dichloroethenes	V																						
Ethyl Benzene	V	5		1 CV		700											680						
Ethylene Dibromide	V			d		0.05											0.0004						
Ethylene Oxide	V																						
Halomethanes	V			1 (g)		100											100						
Methylene Chloride	V	5		CV	5.0 (h)		0 (h)											0.19					
Pyrene	V	10		CS																			
Styrene	V	5		CV		100																	
Tetrachloroethanes	V	5		1 CV		5												0.8					
Tetrachloroethene	V	5		1 CV		1,000											5						
Toluene	V	5		1 CV		1,000											1,000						

**TABLE B-6. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
GROUNDWATER QUALITY STANDARDS (ug/l)**

					FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
Parameter	Type (5)	PQL MDL		Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goal TBCs (b)	RCRA Subpart F Limit (c)	CDH WQCC Groundwater Quality Standards (d)							
		RFP	CDH		Statewide Table A (d) (7)	Site-Specific (g)											
					Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Women Creek Walnut Creek							
Trichloroethanes	V	5		CV													
Trichloroethene	V	5	1	CV	5		0			5							
Vinyl Acetate	V	10		CV													
Xylenes (total)	V	5		CV		10,000		10,000									

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (e)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH		Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only				
Bicarbonate	A	10,000		E310.1								
Carbonate	A	10,000		E310.1								
Chloride	A	5,000		E325	250,000*				860,000(e)	230,000(e)		
Chlorine	A	1,000		E4500					19	11		
Fluoride	A	5,000		E340	4,000; 2,000*		4,000					4,000
N as Nitrate	A	5,000		E353.1	10,000			10,000			10,000	
N as Nitrate+Nitrite	A	5,000		E353.1		10,000		10,000				
N as Nitrite	A	5,000		E354.1		1,000		1,000				
Sulfate	A	5,000		E375.4	250,000*							
Sulfide	A											
Coliform (Fecal)	B	1		SM9221C	1/100 ml							
Ammonia as N	C	5,000		E350					Criteria are pH			
Dioxin	D			d					0.01	0.00001	0.000000013	0.000000014
Sulfur	E	100,000		E600								
Dissolved Oxygen	FP	500		SM4500					5,000			
pH	FP	0.1		E150.1	6.5-8.5 *					6.5-9		
Specific Conductance	FP	1		E120.1								
Temperature	FP								SS	SS		
Boron	I	5,000		E6010								
Total Dissolved Solids	I	10,000		E160.1	500,000*				SS	SS	250,000	
Aluminum	M	200		CT		50 to 200*			750	87		
Antimony	M	60		CT					9,000	1,600	146	45,000
Arsenic	M	10		CT	50						0.0022	0.0175
Arsenic III	M								360	190		
Arsenic V	M								850	48		
Barium	M	200		CT	1,000	2,000 (f)		2,000 (f)			1,000	
Beryllium	M	5		CT					130	5.3	.0068**	.117**
Cadmium	M	5		CT	10	5		5	3.9 (3)	1.1 (3)	10	
Calcium	M	5,000		CT								

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (e)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH		(a)	(b)	(e)	(b)	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Cesium	M	1,000		NC								
Chromium	M	10		CT	50	100		100				
Chromium III	M	5		SW8467196					1,700	210	170,000	3,433,000
Chromium VI	M	10		E218.5					18	11	50	
Cobalt	M	50		CT								
Copper	M	25		CT	1,000*			1,300 (g)	18 (3)	12 (3)		
Cyanide	M	10		CT					22	5.2	200	
Iron	M	100		CT	300 *					1,000	300	
Lead	M	5		CT	50			0 (g)	82 (3)	3.2 (3)	50	
Lithium	M	100		NC								
Magnesium	M	5000		CT								
Manganese	M	15		CT	50 *						50	100
Mercury	M	0.2		CT	2	2		2	2.4	0.012	0.144	0.148
Molybdenum	M	200		NC								
Nickel	M	40		CT					1,400 (3)	180 (3)	13.4	100
Potassium	M	5000		CT								
Selenium	M	5		CT	10	50		50	20 (d)	5 (d)	10	
Silver	M	10		CT	50	100 *			4.1 (3)	0.12	50	
Sodium	M	5000		CT								
Strontium	M	200		NC								
Thallium	M	10		CT					1,400 (1)	40 (1)	13	48
Tin	M	200		NC								
Titanium	M	10		E6010								
Tungsten	M	10		E6010								
Vanadium	M	50		CT								
Zinc	M	20		CT	5,000 *				120 (3)	110 (3)		
2,4,5-TP Silvex	P		0.5	d	10	50		50				
2,4-Dichlorophenoxyacetic Acid (2,4-D)	P		1	d	100	70		70				
Acrolein	P		10						68(1)	21(1)	320	780
Aldicarb	P		10					1 (f)				

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Aldrin	P	0.05	0.1	CP					3.0		0.000074	0.000079
Bromacil	P											
Carbofuran	P			d		40		40				
Chloranil												
Chlordane (Alpha)	P	0.5	1	CP		2		0	2.4	0.0043	0.00048	0.00048
Chlordane (Gamma)	P	0.5	1	CP		2		0	2.4	0.0043	0.00048	0.00048
Chlorpyrifos	P		0.1	E619					0.083	0.041		
DDT	P	0.1	0.1	CP					1.1	0.0011	0.000024	0.000024
DDT metabolite (DDD)	P	0.1	0.1	CP					0.06			
DDT metabolite (DDE)	P	0.1	0.1	CP					1,050			
Demeton	P		1							0.1		
Diazinon	P											
Dieldrin	P	0.1	0.1	CP					2.5	0.0019	0.00007	0.000078
Endosulfan I	P	0.05	0.1	CP					0.22	0.056	74	159
Endosulfan II	P	0.1	0.1	CP								
Endosulfan Sulfate	P	0.1	0.1	CP								
Endrin	P	0.1	0.1	CP	0.2				0.18	0.0023	1	
Endrin Aldehyde	P		0.1									
Endrin Ketone	P	0.1		CP								
Guthion	P		1.5							0.01		
Heptachlor	P	0.05	0.05	CP		0.4		0	0.52	0.0038	0.00028	0.00029
Heptachlor Epoxide	P	0.05	0.05	CP		0.2		0				
Hexachlorocyclohexane, Alpha	P	0.05	0.05	CP							0.0092	0.031
Hexachlorocyclohexane, Beta	P	0.05	0.05	CP							0.0163	0.0547
Hexachlorocyclohexane, BHC	P	0.05	0.05									
Hexachlorocyclohexane, Delta	P	0.05		CP								
Hexachlorocyclohexane, Technical	P		0.2	f								
Hexachlorocyclohexane, (Lindane) Gama	P	0.05	0.05	CP	4	0.2		0.2	2.0	0.08	0.0123	0.0414
Malathion	P		0.2							0.01		
Methoxychlor	P	0.5	0.5	CP	100	40		40		0.03	100	
Mirex	P		0.1							0.001		

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (c)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Parathion	P								0.065	0.013		
PCBs	P	0.5	1	CP		0.5		0	2.0	0.014	0.000079**	0.000079**
Simazine	P			e								
Toxaphene	P	1	5	CP		3		0	0.73	0.0002	0.00071**	0.00073**
Vaponite 2	P											
Aroclor 1016	PP	0.5		CP								
Aroclor 1221	PP	0.5		CP								
Aroclor 1232	PP	0.5		CP								
Aroclor 1242	PP	0.5		CP								
Aroclor 1248	PP	0.5		CP								
Aroclor 1254	PP	1		CP								
Aroclor 1260	PP	1		CP								
Atrazine	PP			e		3		3				
Americium (pCi/l)	R											
Americium 241 (pCi/l)	R	0.01										
Cesium 134 (pCi/l)	R	1										
Cesium 137 (pCi/l)	R	1										
Gross Alpha (pCi/l)	R	2			15 (10)							15
Gross Beta (pCi/l)	R	4			50 (4 mrem/yr)							
Plutonium (pCi/l)	R											
Plutonium 238+239+240 (pCi/l)	R	0.01										
Radium 226+228 (pCi/l)	R	0.5/0.1 (9)			5							5
Strontium 89+90 (pCi/l)	R	1										
Strontium 90 (pCi/l)	R				8 (6)							8
Thorium 230+232 (pCi/l)	R											
Tritium (pCi/l)	R				20,000 (6)							
Uranium 233+234 (pCi/l)	R											
Uranium 235 (pCi/l)	R	0.6										
Uranium 238 (pCi/l)	R	0.6										
Uranium (total) (pCi/l)	R											

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
1,2,4,5-Tetrachlorobenzene	SV		10	b							38	48
1,2,4-Trichlorobenzene	SV	10		CS								
1,2-Dichlorobenzene (Ortho)	SV	10	10	CS		600		600				
1,2-Diphenylhydrazine	SV			b					270 (1)			
1,3-Dichlorobenzene (Meta)	SV	10	1	CS								
1,4-Dichlorobenzene (Para)	SV	10	1	CS	75		75					
2,4,5-Trichlorophenol	SV	50		CS							2,800	
2,4,6-Trichlorophenol	SV	10	50	CS						970 (1)	1.2 **	3.6 **
2,4-Dichlorophenol	SV	10	50	CS					2,020 (1)	365 (1)	3,090	
2,4-Dimethylphenol	SV	10	50	CS					2,120 (1)			
2,4-Dinitrophenol	SV	50	50	CS								
2,4-Dinitrotoluene	SV	10	10	CS							0.11 **	9.1 **
2,6-Dinitrotoluene	SV	10	10	CS					330 (1)	230 (1)	70	14,300
2-Chloronaphthalene	SV	10		CS								
2-Chlorophenol	SV	10	50	CS					4,360 (1)	2,000 (1)		
2-Methylnaphthalene	SV	10		CS								
2-Methylphenol	SV	10		CS								
2-Nitroaniline	SV	50		CS								
2-Nitrophenol	SV	10		CS								
3,3-Dichlorobenzidine	SV	20	10	CS							0.01	0.02
3-Nitroaniline	SV	50		CS								
4,6-Dinitro-2-methylphenol	SV	50	50	CS								
4-Bromophenyl Phenylether	SV	10		CS								
4-Chloroaniline	SV	10		CS								
4-Chlorophenyl Phenyl Ether	SV	10		CS								
4-Chloro-3-methylphenol	SV	10	50	CS					30 (1)			
4-Methylphenol	SV	10		CS								
4-Nitroaniline	SV	50		CS								
4-Nitrophenol	SV	50		CS					230 (1)	150 (1)		
Acenaphthene	SV	10	10	CS					1,700 (1)	520 (1)		

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH		Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only				
Anthracene	SV	10	1	CS					2,500		0.00012	0.00053
Benzidine	SV		1	d								
Benzoic Acid	SV	50		CS								
Benzo(a)anthracene	SV	10	10	CS								
Benzo(a)pyrene	SV	10	10	CS								
Benzo(b)fluoranthene	SV	10	10	CS								
Benzo(g,h,i)perylene	SV	10	10	CS								
Benzo(k)fluoranthene	SV	10	10	CS								
Benzyl Alcohol	SV	10		CS								
bis(2-Chloroethoxy)methane	SV	10		CS								
bis(2-Chloroethyl)ether	SV	10	10	CS							0.03**	1.36 **
bis(2-Chloroisopropyl)ether	SV	10	10	CS							34.7	4,360
bis(2-Ethylhexyl)phthalate	SV	10	10	CS							15,000	50,000
Butadiene	SV											
Butylbenzylphthalate	SV	10	10	CS								
Chlorinated Ethers	SV											
Chlorinated Naphthalenes	SV								1,800 (1)			
Chloroalkylethers	SV	10		CS					238,000 (1)			
Chlorophenol	SV		50									
Chrysene	SV	10	10	CS								
Dibenzofuran	SV	10		CS								
Dibenz(a,h)anthracene	SV	10	10	CS								
Dichlorobenzenes	SV		1						1,120 (1)	763 (1)	400	2,800
Dichlorobenzidine	SV	20	10	CS							0.01	0.02
Diethylphthalate	SV	10	10	CS							350,000	1,800,000
Dimethylphthalate	SV	10	10	CS							313,000	2,900,000
Di-n-butylphthalate	SV	10	10	CS								
Di-n-octylphthalate	SV	10		CS								
Ethylene Glycol	SV			d								
Fluoranthene	SV	10	10	CS					3,980 (1)		42	54
Fluorene	SV	10	10	CS								

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Formaldehyde	SV											
Haloethers	SV											
Hexachlorobenzene	SV	10	10	CS					380 (1)	122 (1)		
Hexachlorobutadiene	SV	10	10	CS					90 (1)	9.3 (1)	0.00072**	0.00074**
Hexachlorocyclopentadiene	SV	10	10	CS					7 (1)	5.2 (1)	0.45**	50 **
Hexachloroethane	SV	10	10	CS					980 (1)	540 (1)	208	8.74
Hydrazine	SV											
Indeno(1,2,3-cd)pyrene	SV	10	10	CS								
Isophorone	SV	10	10	CS					117,000 (1)		5,200	520,000
Naphthalene	SV	10	10	CS					2,300 (1)	820 (1)		
Nitrobenzene	SV	10	10	CS					27,000 (1)		19,800	
Nitrophenols	SV								230 (1)	150 (1)		
Nitrosamines	SV								5,850 (1)			
Nitrosodibutylamine	SV		10	b							0.0064	0.587
Nitrosodiethylamine	SV		10	b							0.0008	1.24
Nitrosodimethylamine	SV		10	b							0.0014	16
Nitrosopyrrolidine	SV		10	b							0.018	91.9
N-Nitrosodiphenylamine	SV	10	10	b							4.9 **	16.1 **
N-Nitroso-di-n-dipropylamine	SV	10	10	b								
Pentachlorinated Ethanes	SV			b					7,240 (1)	1,100 (1)		
Pentachlorobenzene	SV		10	b							74	85
Pentachlorophenol	SV	50	50	CS		1 (f)		0 (f)	20 (4)	13 (4)	1,010	
Phenanthrene	SV	10	10	CS								
Phenol	SV	10	50	CS					10,200 (1)	2,560 (1)	3,500	
Phthalate Esters	SV			e					940 (1)	3 (1)		
Polynuclear Aromatic Hydrocarbons	SV		10	b							0.0028**	0.0311**
Vinyl Chloride	SV	10	2	CV	2		0				2 **	525 **
1,1,1-Trichloroethane	V	5	1	CV	200		200				18,400	1,030,000
1,1,1,2-Tetrachloroethane	V	5	1	CV						2,400	0.17**	10.7 **
1,1,2-Trichloroethane	V	5	1	CV						9,400	0.6**	41.8 **

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH		Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only				
1,1-Dichloroethane	V	5		CV								
1,1-Dichloroethene	V	5	1	CV	7		7					
1,2-Dichloroethane	V	5	1	CV	5		0		118,000	20,000	0.94**	243 **
1,2-Dichloroethene (cis)	V		1	a		70		70				
1,2-Dichloroethene (total)	V	5		CV								
1,2-Dichloroethene (trans)	V	5	1	a		100		100				
1,2-Dichloropropane	V	5	1	CV		5		0	23,000	5,700		
1,3-Dichloropropene (cis)	V	5	1	CV					6,060	244 (1)	87	14,100
1,3-Dichloropropene (trans)	V	5	1	CV					6,060	244 (1)	87	14,100
2-Butanone	V	10		CV								
2-Hexanone	V	10		CV								
4-Methyl-2-pentanone	V	10		CV								
Acetone	V	10		CV								
Acrylonitrile	V		5	c					7,500	2,600	0.058	0.65
Benzene	V	5	1	CV	5		0		5,300		0.66**	40 **
Bromodichloromethane	V	5	1	CV								
Bromoform	V	5	1	CV								
Bromomethane	V	10	1	CV								
Carbon Disulfide	V	5		CV								
Carbon Tetrachloride	V	5	1	CV	5		0		35,200 (1)		0.4**	6.94 **
Chlorinated Benzenes	V	10		CV/CS					250 (1)	50 (1)		
Chlorobenzene	V	5	1	CV/CS		100		100				
Chloroethane	V	10		CV								
Chloroform	V	5	1	CV	Tot THM<100 (2)				28,900 (1)	1,240 (1)	0.19 **	15.7 **
Chloromethane	V	10	1	CV								
Dibromochloromethane	V	5	1	CV								
Dichloroethenes	V		1						11,600 (1)		0.033**	1.85 **
Ethyl Benzene	V	5	1	CV		700		700	32,000 (1)		1,400	3,280
Ethylene Dibromide	V			d		0.05		0				
Ethylene Oxide	V											
Halomethanes	V				100				11,000 (1)		0.19**	15.7 **

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (e)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH		Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only				
Methylene Chloride	V	5	1	CV								
Pyrene	V	10	10	CS								
Styrene	V	5		CV		100		100				
Tetrachloroethanes	V	5	1	CV					9,320 (1)			
Tetrachloroethene	V	5	1	CV		5		0	5,280 (1)	840 (1)	0.80**	8.85 **
Toluene	V	5	1	CV		1,000		1,000	17,500 (1)		14,300	424,000
Trichloroethanes	V	5	1	CV					18,000 (1)			
Trichloroethene	V	5	1	CV	5		0		45,000 (1)	21,900 (1)	2.7 **	80.7 **
Vinyl Acetate	V	10		CV								
Xylenes (total)	V	5		CV		10,000		10,000				

EXPLANATION OF TABLE

+ = note that values in this table are current as of October 30, 1992

* = secondary maximum contaminant level, TBCs

** = Human health criteria for carcinogens reported for three risk levels. Value presented is the 10-5 risk level.

AWQC	= Ambient Water Quality Criteria
CLP	= Contract Laboratory Program
CWA	= Clean Water Act
EPA	= Environmental Protection Agency
MDL	= Minimum Detection Limit for radionuclides (pCi/l)
pCi/l	= picocuries per liter
PCB	= polychlorinated biphenyl
PQL	= Practical Quantitation Level
SDWA	= Safe Drinking Water Act
SS	= Species Specific
TAL	= Target Analyte List
THM	= Total Trihalomethanes
TIC	= Tentatively Identified Compound
ug/l	= micrograms per liter
VOA	= Volatile Organic Analysis

(1) criteria not developed; value presented is lowest observed effects level (LOEL)

(2) total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane

(3) hardness dependent criteria

(4) pH dependent criteria (7.8 pH used)

(5) standard is not adequately protective when chloride is associated with potassium, calcium, or magnesium, rather than sodium.

(6) if both strontium-90 and tritium are present, the sum of their annual dose equivalents to bone marrow shall not exceed 4 mrem/yr.

(7) type abbreviations are: A=anion; B=bacteria; C=cation; D=dioxin; E=element; I=indicator; FP=field parameter; M=metal; P=pesticide; PP=pesticide/PCB;
R=radionuclide; SV=semi-volatile; V=volatile

(8) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TIC in CS;
c = detected as TIC in CV; d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.

**TABLE B-7. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)**

Parameter	Type (7)	PQL MDL		Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life (c)		CWA AWQC for Protection of Human Health (c)	
		RFP	CDH						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only

(9) MDL for radium 226 is 0.5; MDL for radium 228 is 1.0

(10) Value for gross alpha excludes uranium

(a) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990). Segment 4 MCLs are ARAR; Segment 5 MCLs are TBC; all MCLGs are TBC.

(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142 and 143, Final Rule, effective July 30, 1992 (56 Federal Register 3526; 1/30/1991).

(c) EPA, Quality Criteria for Protection of Aquatic Life, 1986

(d) EPA, National Ambient Water Quality Criteria for Selenium - 1987

(e) EPA, National Ambient Water Quality Criteria for Chloride - 1988

(f) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, and 143, Final Rule (56 FR 30266; 7/1/1991) effective 1/1/1993.

(g) EPA Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper, 40 CFR 141 and 142 (56 FR 26460; 6/7/1991) effective 12/7/91.

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)														Basin Standards (b)	
Parameter	Type (5)	PQL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)		
		MDL RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (4)	Aquatic Life	Water Supply	
									Acute Value (2)	Chronic Value (2)					
Bicarbonate	A	10,000		E310.1											
Carbonate	A	10,000		E310.1											
Chloride	A	5,000		E325									250,000		
Chlorine	A	1,000		E4500					19	11					
Fluoride	A	5,000		E340									2,000		
N as Nitrate	A	5,000		E353.1								100,000	10,000		
N as Nitrate + Nitrite	A	5,000		E353.1								100,000	10,000		
N as Nitrite	A	5,000		E354.1					SS	SS		10,000	1,000		
Sulfate	A	5,000		E375.4									250,000		
Sulfide	A									2			50		
Coliform (Fecal)	B	1		SM9221C									2000/100 ml		
Ammonia as N	C	5,000		E350					620	60			500		
Dioxin	D			d	0.00000022	0.000000013	0.01	0.00001							
Sulfur	E	100,000		E600											
Dissolved Oxygen	FP	500		SM4500					5,000	5,000	3,000		3,000		
pH	FP	0.1		E150.1					6.5-9.0	6.5-9.0			5.0-9.0		
Specific Conductance	FP	1		E120.1											
Temperature	FP								30 degrees	30 degrees					
Boron	I	5,000		E6010							750				
Total Dissolved Solids	I	10,000		E160.1											
Aluminum	M	200		CT					750	87					
Antimony	M	60		CT									14		
Arsenic	M	10		CT					360	150	100		50		
Arsenic III	M														
Arsenic V	M														
Barium	M	200		CT									1,000		
Beryllium	M	5		CT							100		0.0076		

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)													Basin Standards (b)	
Parameter	Type (5)	PQL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I, II, III (1)				Organics (7)	
		MDL RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricul- tural Standard (3)	Domestic Water Supply (4)	Aquatic Life	Water Supply
									Acute Value (2)	Chronic Value (2)				
Cadmium	M	5		CT					TVS	TVS	10	10		
Calcium	M	5,000		CT										
Cesium	M	1,000		NC										
Chromium	M	10		CT										
Chromium III	M	5		SW8467196					TVS	TVS	100	50		
Chromium VI	M	10		E218.5					16	11	100	50		
Cobalt	M	50		CT										
Copper	M	25		CT					TVS	TVS	200	1,000		
Cyanide	M	10		CT					5	5	200	200		
Iron	M	100		CT						1,000		300 (dis)		
Lead	M	5		CT					TVS	TVS	100	50		
Lithium	M	100		NC										
Magnesium	M	5000		CT										
Manganese	M	15		CT						1,000	200	50 (dis)		
Mercury	M	0.2		CT					2.4	0.1		2.0		
Molybdenum	M	200		NC										
Nickel	M	40		CT					TVS	TVS	200			
Potassium	M	5000		CT										
Selenium	M	5		CT					135	17	20	10		
Silver	M	10		CT					TVS	TVS		50		
Sodium	M	5000		CT										
Strontium	M	200		NC										
Thallium	M	10		CT						15		0.012		
Tin	M	200		NC										
Titanium	M	10		E6010										
Tungsten	M	10		E6010										
Vanadium	M	50		CT										
Zinc	M	20		CT					TVS	TVS	2,000	5,000		

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

							Statewide Standards (a)						Basin Standards (b)	
Parameter	Type (5)	PQL MDL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)	
		RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (4)		
									Acute Value (2)	Chronic Value (2)				
2,4,5-TP Silvex	P		0.5	d	50									
2,4-D	P		1	d	70									100
Acrolein			10			320	68	21						
Aldicarb	P		10		10									
Aldrin	P	0.05	0.1	CP	0.002 (8)	0.00013	1.5						0.003	
Bromacil	P													
Carbofuran	P			d	36									
Chloranil	P			E619										
Chlordane (Alpha)	P	0.5	1	CP	0.03 (8)		1.2	0.0043						
Chlordane (Gamma)	P	0.5	1	CP	0.03 (8)	0.00058	1.2	0.0043						
Chlorpyrifos	P		0.1				0.083	0.041						
DDT	P	0.1	0.1	CP	0.1	0.00059	0.55	0.001					0.001	
DDT Metabolite (DDD)	P	0.1	0.1	CP		0.0008	0.6						0.001	
DDT Metabolite (DDE)	P	0.1	0.1	CP	0.1	0.00059	1,050						0.001	
Demeton	P		1					0.1					0.1	
Diazinon	P													
Dieldrin	P	0.1	0.1	CP	0.002	0.00014	1.3	0.0019					0.003	
Endosulfan I	P	0.05	0.1	CP		0.93	0.11	0.056					0.003	
Endosulfan II	P	0.1	0.1	CP			0.93							
Endosulfan Sulfate	P	0.1	0.1	CP										
Endrin	P	0.1	0.1	CP	0.2		0.09	0.0023					0.004	
Endrin Aldehyde	P		0.1		0.2	0.2								
Endrin Ketone	P	0.1		CP										
Guthion	P		1.5					0.01					0.01	
Heptachlor	P	0.05	0.05	CP	0.008	0.00021	0.26	0.0038					0.001	0.2
Heptachlor Epoxide	P	0.05	0.05	CP	0.09	0.0001	0.26	0.0038						
Hexachlorocyclohexane, Alpha	P	0.05	0.05	CP	0.006		0.0039							
Hexachlorocyclohexane, Beta	P	0.05	0.05	CP		0.014								
Hexachlorocyclohexane, BHC	P	0.05	0.05				100							
Hexachlorocyclohexane, Delta	P	0.05		CP										
Hexachlorocyclohexane, Tech.	P		0.2	f		0.012								

TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Statewide Standards (a)																	Basin Standards (b)	
Parameter	Type (5)	PQL MDL RFP	Human Health Carcinogens/Noncarcinogens (2) (6)			Aquatic Life (8)		Tables I, II, III (3)			Organics (7)			Water Supply				
			Method (6)	CDH	Water Supply	Fish	Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (4)						
Hexachlorocyclohexane, Lindane	P	0.05	0.05	CP	0.2	0.019	1.0	0.08					0.01	4.0				
Malathion	P		0.2					0.1					0.1					
Methoxychlor	P	0.5	0.5	CP	40			0.03					0.03	100				
Mirex	P		0.1					0.001					0.001					
Parathion	P												0.04					
PCBs	P	0.5	1	CP	0.005	0.000044	2.0	0.014					0.001	4.0				
Simazine	P												4.0	5.0				
Toxaphene	P	1	5	CP	0.03	0.00073	0.73	0.0002					0.005					
Vapontite 2	P																	
Aroclor 1016	PP	0.5		CP														
Aroclor 1221	PP	0.5		CP														
Aroclor 1232	PP	0.5		CP														
Aroclor 1242	PP	0.5		CP														
Aroclor 1248	PP	0.5		CP														
Aroclor 1254	PP	1		CP														
Aroclor 1260	PP	1		CP														
Atrazine	PP												3.0	3.0				
Americium (pCi/l)	R																	
Americium 241 (pCi/l)	R	0.01																
Cesium 134 (pCi/l)	R	1			80 (10)													
Cesium 137 (pCi/l)	R	1																
Gross Alpha (pCi/l)	R	2																
Gross Beta (pCi/l)	R	4																
Plutonium (pCi/l)	R																	
Plutonium 238+239+240 (pCi/l)	R	0.01			15 (10)													
Radium 226+228 (pCi/l)	R	0.5/1 (9)			5 (10)													
Strontium 89+90 (pCi/l)	R	1																
Strontium 90 (pCi/l)	R				8 (10)													
Thorium 230+232 (pCi/l)	R				60 (10)													

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)														Basin Standards (b)	
Parameter	Type (5)	PQL MDL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)		
		RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (4)			
									Acute Value (2)	Chronic Value (2)					
Tritium (pCi/l)	R				20,000 (10)										
Uranium 233 + 234 (pCi/l)	R														
Uranium 235 (pCi/l)	R	0.6													
Uranium 238 (pCi/l)	R	0.6													
Uranium (Total) (pCi/l)	R								TVS	TVS					
1,2,4,5-Tetrachlorobenzene	SV		10	b	2 (8)										
1,2,4-Trichlorobenzene	SV	10		CS											
1,2-Dichlorobenzene (Ortho)	SV	10	1	CS	620	620									
1,2-Diphenylhydrazine	SV			b	0.05	0.04	270								
1,3-Dichlorobenzene (Meta)	SV	10	1	CS	620	400									
1,4-Dichlorobenzene (Para)	SV	10	1	CS	75	75									
2,4,5-Trichlorophenol	SV	50		CS											
2,4,6-Trichlorophenol	SV	10	50	CS	2	2		970							
2,4-Dichlorophenol	SV	10	50	CS	21	21	2,020	365							
2,4-Dimethylphenol	SV	10	50	CS			2,120								
2,4-Dinitrophenol	SV	50	50	CS	14	14									
2,4-Dinitrotoluene	SV	10	10	CS		0.11									
2,6-Dinitrotoluene	SV	10	10	CS			330	230							
2-Chloronaphthalene	SV	10		CS											
2-Chlorophenol	SV	10	50	CS			4,380	2,000							
2-Methylnaphthalene	SV	10		CS											
2-Methylphenol	SV	10		CS											
2-Nitroaniline	SV	50		CS											
2-Nitrophenol	SV	10		CS											
3,3-Dichlorobenzidine	SV	20	10	CS		0.039									
3-Nitroaniline	SV	50		CS											
4,6-Dinitro-2-methylphenol	SV	50	50	CS		13									
4-Bromophenyl Phenylether	SV	10		CS											
4-Chloroaniline	SV	10		CS											

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992)+
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)													Basin Standards (b)		
Parameter	Type (5)	PQL MDL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)		
		RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (4)	Aquatic Life	Water Supply	
									Acute Value (2)	Chronic Value (2)					
4-Chlorophenyl Phenyl Ether	SV	10		CS											
4-Chloro-3-methylphenol	SV	10	50	CS			30								
4-Methylphenol	SV	10		CS											
4-Nitroaniline	SV	50		CS											
4-Nitrophenol	SV	50		CS											
Acenaphthene	SV	10	10	CS			1,700	520							
Anthracene	SV	10	1	CS		0.0028									
Benzidine	SV		10	d	0.0002	0.00012(8)	2,500							0.1	0.01
Benzoic Acid	SV	50		CS											
Benzo(a)anthracene	SV	10	10	CS		0.0028									
Benzo(a)pyrene	SV	10	10	CS		0.0028									
Benzo(b)fluoranthene	SV	10	10	CS		0.0028									
Benzo(g,h,i)perylene	SV	10	10	CS		0.0028									
Benzo(k)fluoranthene	SV	10	10	CS		0.0028									
Benzyl Alcohol	SV	10		CS											
bis(2-Chloroethoxy)methane	SV	10		CS											
bis(2-Chloroethyl)ether	SV	10	10	CS	0.03 (8)	0.03 (8)									
bis(2-Chloroisopropyl)ether	SV	10	10	CS		1,400									
bis(2-Ethylhexyl)phthalate	SV	10	10	CS		1.8 (8)									
Butadiene	SV														
Butyl Benzylphthalate	SV	10	10	CS		3,000									
Chlorinated Ethers	SV														
Chlorinated Napthalenes	SV														
Chloroalkylethers	SV	10		CS											
Chlorophenol	SV		50											1.0	1.0
Chrysene	SV	10	10	CS		0.0028									
Dibenzofuran	SV	10		CS											
Dibenz(a,h)anthracene	SV	10	10	CS		0.0028									
Dichlorobenzenes	SV		1												
Dichlorobenzidine	SV	20	10	CS		0.039									

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)														Basin Standards (b)	
Parameter	Type (5)	PQL MDL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)		
		RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricul- tural Standard (3)	Domestic Water Supply (4)	Aquatic Life	Water Supply	
Diethylphthalate	SV	10	10	CS		23,000									
Dimethylphthalate	SV	10	10	CS		313,000									
Di-n-butylphthalate	SV	10	10	CS		2,700									
Di-n-octylphthalate	SV	10		CS											
Ethylene Glycol	SV			d											
Fluoranthene	SV	10	10	CS		42	3,980								
Fluorene	SV	10	10	CS		0.0028									
Formaldehyde	SV														
Haloethers	SV														
Hexachlorobenzene	SV	10	10	CS	6	0.00072									
Hexachlorobutadiene	SV	10	10	CS	1	0.45	90	9.3							
Hexachlorocyclopentadiene	SV	10	10	CS		240	7	5							
Hexachloroethane	SV	10	10	CS		1.9	980	540							
Hydrazine	SV														
Indeno(1,2,3-cd)pyrene	SV	10	10	CS		0.0028									
Isophorone	SV	10	10	CS	1,050	8.4	117,000								
Naphthalene	SV	10	10	CS		0.0028	2,300	620							
Nitrobenzene	SV	10	10	CS	3.5	3.5	27,000								
Nitrophenols	SV														
Nitrosamines	SV														
Nitrosodibutylamine	SV		10	b		0.0064									
Nitrosodiethylamine	SV		10	b		0.0008									
Nitrosodimethylamine	SV		10	b		0.00069									
Nitrosopyrrolidine	SV		10	b		0.016									
N-Nitrosodiphenylamine	SV	10	10	CSb		4.9									
N-Nitroso-di-n-dipropylamine	SV	10	10	CSb		0.005									
Pentachlorinated Ethanes	SV			b											
Pentachlorobenzene	SV		10	b	6 (8)										
Pentachlorophenol	SV	50	50	CS	200		9	5.7							
Phenanthrene	SV	10	10	CS		0.0028									

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)													Basin Standards (b)	
Parameter	Type (5)	PQL MDL		Method (e)	Human Health Carcinogens/ Noncarcinogens (2) (6)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)	
		RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (4)	Aquatic Life	Water Supply
									Acute Value (2)	Chronic Value (2)				
Phenol	SV	10	50	CS		21,000	10,200	2,560					500	1.0
Phthalate Esters	SV			e										
Polynuclear Aromatic Hydrocarbons	SV		10	b		0.0028								
Vinyl Chloride	SV	10	2	CV	2	2								
1,1,1-Trichloroethane	V	5	1	CV	200	200								
1,1,2,2-Tetrachloroethane	V	5	1	CV		0.17		2,400						
1,1,2-Trichloroethane	V	5	1	CV	3	0.6	9,400							
1,1-Dichloroethane	V	5		CV										
1,1-Dichloroethene	V	5	1	CV	7	0.057								
1,2-Dichloroethane	V	5	1	CV	0.4	0.4	118,000	20,000						
1,2-Dichloroethene (cis)	V		1	a	70									
1,2-Dichloroethene (total)	V	5		CV										
1,2-Dichloroethene (trans)	V	5	1	a	100									
1,2-Dichloropropane	V	5	1	CV	0.56 (8)	0.56	23,000	5,700						
1,3-Dichloropropene (cis)	V	5	1	CV		10	6,060	244						
1,3-Dichloropropene (trans)	V	5	1	CV		10	6,060	244						
2-Butanone	V	10		CV										
2-Hexanone	V	10		CV										
4-Methyl-2-pentanone	V	10		CV										
Acetone	V	10		CV										
Acrylonitrile	V		5	c		0.58	7,550	2,600						
Benzene	V	5	1	CV	1	1	5,300							
Bromodichloromethane	V	5	1	CV	0.3	0.3								
Bromoform	V	5	1	CV	4	4								
Bromomethane	V	10	1	CV		48								
Carbon Disulfide	V	5		CV										
Carbon Tetrachloride	V	5	1	CV	0.3	0.25	35,200							
Chlorinated Benzenes	V	10		CV/CS										
Chlorobenzene	V	5	1	CV/CVS	100	100								

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)													Basin Standards (b)	
Parameter	Type (5)	PQL MDL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)	
		RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (4)		
									Acute Value (2)	Chronic Value (2)				
Chloroethane	V	10		CV										
Chloroform	V	5	1	CV	6	6	28,900	1,240						
Chloromethane	V	10	1	CV		5.7								
Dibromochloromethane	V	5	1	CV	14	6								
Dichloroethenes	V		1											
Ethyl Benzene	V	5	1	CV	680	3,100	32,000							
Ethylene Dibromide	V			d										
Ethylene Oxide	V													
Halomethanes	V				100									
Methylene Chloride	V	5	1	CV		4.7								
Pyrene	V	10	10	CS		0.0028								
Styrene	V	5		CV										
Tetrachloroethanes	V	5	1	CV										
Tetrachloroethene	V	5	1	CV	5	0.8	5,280	840						
Toluene	V	5	1	CV	1,000	1,000	17,500							
Trichloroethanes	V	5	1	CV										
Trichloroethene	V	5	1	CV	5	2.7	45,000	21,900						
Vinyl Acetate	V	10		CV										
Xylenes (Total)	V	5		CV										

EXPLANATION OF TABLE

+ = note that values in this table are current as of October 30, 1992

CLP = Contract Laboratory Program

CDH = Colorado Department of Health

dis = dissolved

EPA = Environmental Protection Agency

MDL = Minimum Detection Limit for radionuclides (pCi/l)

pCi/l = picocuries per liter

PCB = polychlorinated biphenyl

PQL = Practical Quantitation Level

SS = species specific

TAL = Target Analyte List

THM = Total Trihalomethanes

TIC = Tentatively Identified Compound

**TABLE B-8. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (September 30, 1992) +
STATEWIDE AND BASIN (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Statewide Standards (a)											Basin Standards (b)			
Parameter	Type (5)	PQL		Method (6)	Human Health Carcinogens/ Noncarcinogens (2) (8)		Aquatic Life (8)		Tables I,II,III (1)				Organics (7)	
		MDL RFP	CDH		Water Supply	Water and Fish	Acute Value	Chronic Value	Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (4)		
									Acute Value (2)	Chronic Value (2)				
													Water Supply	Water and Fish

TVS = Table Value Standard (hardness dependent), see Table III in (a)
ug/l = micrograms per liter
VOA = Volatile Organic Analysis
WQCC = Water Quality Control Commission

(1) Table I = physical and biological parameters

Table II = inorganic parameters

Table III = metal parameters

Values in Tables I, II, and III for recreational uses, cold water biota and domestic water supply are not included.

(2) In the absence of specific, numeric standards for non-naturally occurring organics, the narrative standard is interpreted as zero with enforcement based on practical quantification levels (PQLs) as defined by CDH/WQCC or EPA

(3) All are 30-day standards except for nitrate + nitrite

(4) Ammonia, sulfide, chloride, sulfate, copper, iron, manganese, and zinc are 30-day standards, all others are 1-day standards

(5) type abbreviations are: A=anion; B=bacteria; C=cation; I=indicator; FP=field parameter; M=metal; P=pesticide; PP=pesticide/PCB; R=radionuclide; SV=semi-volatile; V=volatile

(6) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV;

b = detected as TICs in CS; c = detected as TIC in CV; d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.

(7) See Section 3.8.5 (2)(a) in (b)

(8) Where standard is below (more stringent than) PQL (CDH), PQL is standard.

(9) MDL for Radium 226 is 0.5; MDL for Radium 228 is 1.0

(10) See section 3.1.11 (f) (2) in (a)

(a) CDH/WQCC, Colorado Water Quality Standards 3.1.0 (5 CCR 1002-8) 1/15/1974; amended 10/17/1991 (ARAR).

(Environmental Reporter 726:1001-1020:6/1990)

(b) CDH/WQCC, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0 (5 CCR 1002-8) 4/6/1981; amended 7/16/92 - Basin-wide standards are ARAR.

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Segment 4 & 5 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (5)	PQL MDL		Method (6)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	CDH					Acute Value	Chronic Value	Woman Creek	Walnut Creek
Bicarbonate	A	10,000		E310.1							
Carbonate	A	10,000		E310.1							
Chloride	A	5,000		E325				250,000	250,000		
Chlorine	A	1,000		E4500				3	3		
Fluoride	A	5,000		E340							
N as Nitrate	A	5,000		E353.1				10,000	10,000		
N as Nitrate+Nitrite	A	5,000		E353.1							
N as Nitrite	A	5,000		E354.1				1,000	1,000		
Sulfate	A	5,000		E375.4				250,000	250,000		
Sulfide	A										
Coliform (Fecal)	B	1		SM9221C							
Ammonia as N	C	5,000		E350				620	60		
Dioxin	D			d	0.00000022	0.00000013			0.00000013		
Sulfur	E	100,000		E600				2.0	2.0		
Dissolved Oxygen	FP	500		SM4500				5,000	5,000		
pH	FP	0.1		E150.1				6.5-9	6.5-9		
Specific Conductance	FP	1		E120.1							
Temperature	FP										
Boron	I	5,000		E6010				750	750		
Total Dissolved Solids	I	10,000		E160.1							
Aluminum	M	200		CT							
Antimony	M	60		CT							
Arsenic	M	10		CT				50			
Arsenic III	M										
Arsenic V	M										
Barium	M	200		CT							
Beryllium	M	5		CT							

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Segment 4 & 5 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (6)	PQL MDL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	CDH					Acute Value	Chronic Value	Woman Creek	Walnut Creek
Cadmium	M	5		CT				TVS	TVS		
Calcium	M	5,000		CT							
Cesium	M	1,000		NC							
Chromium	M	10		CT							
Chromium III	M	5		SW8467196				50			
Chromium VI	M	10		E218.5				TVS	TVS		
Cobalt	M	50		CT							
Copper	M	25		CT				TVS	TVS		
Cyanide	M	10		CT				5	5		
Iron	M	100		CT					300 (3)		
Lead	M	5		CT				TVS	TVS		
Lithium	M	100		NC							
Magnesium	M	5000		CT							
Manganese	M	15		CT					50 (3)		
Mercury	M	0.2		CT					0.01		
Molybdenum	M	200		NC							
Nickel	M	40		CT				TVS	TVS		
Potassium	M	5000		CT							
Selenium	M	5		CT				10			
Silver	M	10		CT				TVS	TVS		
Sodium	M	5000		CT							
Strontium	M	200		NC							
Thallium	M	10		CT							
Tin	M	200		NC							
Titanium	M	10		E6010							
Tungsten	M	10		E6010							
Vanadium	M	50		CT							
Zinc	M	20		CT				TVS	TVS		
2,4,5-TP Silvex	P		0.5	d	10						

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Segment 4 & 5 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (6)	PQL MDL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclides	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	CDH					Acute Value	Chronic Value	Woman Creek	Walnut Creek
2,4-D	P		1	d	100						
Acrolein	P		10								
Aldicarb	P		10		10						
Aldrin	P	0.05	0.1	CP	0.002 (6)	0.000074			0.000074		
Bromacil	P										
Carbofuran	P			d	36						
Chloranil	P			E619							
Chlordane (Alpha)	P	0.5	1	CP	0.03 (6)	0.00046			0.00046		
Chlordane (Gamma)	P	0.5	1	CP	0.03 (6)	0.00046			0.00046		
Chlorpyrifos	P		0.1								
DDT	P	0.1	0.1	CP	0.1 (6)	0.000024			0.000024		
DDT Metabolite (DDD)	P	0.1	0.1	CP							
DDT Metabolite (DDE)	P	0.1	0.1	CP							
Demeton	P		1								
Diazinon	P										
Dieldrin	P	0.1	0.1	CP	0.002 (6)	0.000071			0.000071		
Endosulfan I	P	0.05	0.1	CP							
Endosulfan II	P	0.1	0.1	CP							
Endosulfan Sulfate	P	0.1	0.1	CP							
Endrin	P	0.1	0.1	CP	0.2						
Endrin Aldehyde	P		0.1								
Endrin Ketone	P	0.1		CP							
Guthion	P		1.5								
Heptachlor	P	0.05	0.05	CP	0.008 (6)	0.00028			0.00028		
Heptachlor Epoxide	P	0.05	0.05	CP	0.004 (6)						
Hexachlorocyclohexane, Alpha	P	0.05	0.05	CP		0.0092			0.0092		
Hexachlorocyclohexane, Beta	P	0.05	0.05	CP		0.0163			0.0163		
Hexachlorocyclohexane, BHC	P	0.05	0.05								
Hexachlorocyclohexane, Delta	P	0.05		CP							
Hexachlorocyclohexane, Tech.	P		0.2	f		0.0123			0.0123		

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Segment 4 & 5 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (6)	PQL MDL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	GDH					Acute Value	Chronic Value	Woman Creek	Walnut Creek
Hexachlorocyclohexane, Lindane	P	0.05	0.05	CP	4	0.0186			0.0186		
Malathion	P		0.2								
Methoxychlor	P	0.5	0.5	CP	100						
Mirex	P		0.1								
Parathion	P										
PCBs	P	0.5	1	CP	0.005 (6)	0.000079			0.000079		
Simazine	P			e		4			4		
Toxaphene	P	1	5	CP	5						
Vaponite 2	P										
Aroclor 1016	PP	0.5		CP							
Aroclor 1221	PP	0.5		CP							
Aroclor 1232	PP	0.5		CP							
Aroclor 1242	PP	0.5		CP							
Aroclor 1248	PP	0.5		CP							
Aroclor 1254	PP	1		CP							
Aroclor 1260	PP	1		CP							
Atrazine	PP			e		3			3		
Americium (pCi/l)	R									0.05	0.05
Americium 241 (pCi/l)	R	0.01					30				
Cesium 134 (pCi/l)	R	1			80		80			80	80
Cesium 137 (pCi/l)	R	1									
Gross Alpha (pCi/l)	R	2								7	11
Gross Beta (pCi/l)	R	4								5	19
Plutonium (pCi/l)	R									0.05	0.05
Plutonium 238+239+240 (pCi/l)	R	0.01					15				
Radium 226+228 (pCi/l)	R	0.5/1.0 (5				
Strontium 89+90 (pCi/l)	R	1									
Strontium 90 (pCi/l)	R						8			8	8
Thorium 230+232 (pCi/l)	R						60				

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Segment 4 & 5 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (6)	PQL MDL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	CDH					Acute Value	Chronic Value	Worm Creek	Walnut Creek
Tritium (pCi/l)	R						20,000			500	500
Uranium 233+234 (pCi/l)	R										
Uranium 235 (pCi/l)	R	0.6									
Uranium 238 (pCi/l)	R	0.6									
Uranium (Total) (pCi/l)	R						40			5	10
1,2,4,5-Tetrachlorobenzene	SV		10	b	2 (6)						
1,2,4-Trichlorobenzene	SV	10		CS							
1,2-Dichlorobenzene (Ortho)	SV	10	1	CS	620						
1,2-Diphenylhydrazine	SV			b	0.05 (6)						
1,3-Dichlorobenzene (Meta)	SV	10	1	CS	620						
1,4-Dichlorobenzene (Para)	SV	10	1	CS	75						
2,4,5-Trichlorophenol	SV	50		CS	700						
2,4,6-Trichlorophenol	SV	10	50	CS	2.0 (6)	1.2			1.2		
2,4-Dichlorophenol	SV	10	50	CS	21 (6)						
2,4-Dimethylphenol	SV	10	50	CS							
2,4-Dinitrophenol	SV	50	50	CS							
2,4-Dinitrotoluene	SV	10	10	CS							
2,6-Dinitrotoluene	SV	10	10	CS							
2-Chloronaphthalene	SV	10		CS							
2-Chlorophenol	SV	10	50	CS							
2-Methylnaphthalene	SV	10		CS							
2-Methylphenol	SV	10		CS							
2-Nitroaniline	SV	50		CS							
2-Nitrophenol	SV	10		CS							
3,3-Dichlorobenzidine	SV	20	10	CS		0.01			0.01		
3-Nitroaniline	SV	50		CS							
4,6-Dinitro-2-methylphenol	SV	50	50	CS							
4-Bromophenyl Phenylether	SV	10		CS							
4-Chloroaniline	SV	10		CS							

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992) +
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (e)	FOL		Method (f)	Tables A,B (i)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		MDL	RFP					Acute Value	Chronic Value	Woman Creek	Ward Creek
4-Chlorophenyl Phenyl Ether	SV	10		CS							
4-Chloro-3-methylphenol	SV	10	50	CS							
4-Methylphenol	SV	10		CS							
4-Nitroaniline	SV	50		CS							
4-Nitrophenol	SV	50		CS							
Acenaphthene	SV	10	10	CS							
Anthracene	SV	10	1	CS							
Benidine	SV		10	d	0.0002 (g)	0.00012			0.00012		
Benzoic Acid	SV	50		CS							
Benzo(a)anthracene	SV	10	10	CS							
Benzo(a)pyrene	SV	10	10	CS							
Benzo(b)fluoranthene	SV	10	10	CS							
Benzo(g,h,i)perylene	SV	10	10	CS							
Benzo(k)fluoranthene	SV	10	10	CS							
Benzyl Alcohol	SV	10		CS							
bis(2-Chloroethoxy)methane	SV	10		CS							
bis(2-Chloroethyl)ether	SV	10	10	CS	0.03 (g)	0.0000037			0.0000037		
bis(2-Chloroisopropyl)ether	SV	10	10	CS							
bis(2-Ethylhexyl)phthalate	SV	10	10	CS							
Butadiene	SV										
Butyl Benzylphthalate	SV	10		CS							
Chlorinated Ethers	SV										
Chlorinated Naphthalenes	SV										
Chloroalkylethers	SV	10		CS							
Chlorophenol	SV		50								
Chrysene	SV	10	10	CS							
Dibenzofuran	SV	10		CS							
Dibenz(a,h)anthracene	SV	10	10	CS							
Dichlorobenzenes	SV		1								
Dichlorobenzidine	SV	20	10	CS		0.01			0.01		

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992) +
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Segment 4 & 5 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (6)	POL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		MDL	RFP					Acute Value	Chronic Value	Woman Creek	Walnut Creek
Diethylphthalate	SV	10		CS							
Dimethylphthalate	SV	10		CS							
Di-n-butylphthalate	SV	10		CS							
Di-n-octylphthalate	SV	10		CS							
Ethylene Glycol	SV			d							
Fluoranthene	SV	10		CS							
Fluorene	SV	10		CS							
Formaldehyde	SV										
Haloethers	SV										
Hexachlorobenzene	SV	10		CS	0.02 (6)	0.00072			0.00072		
Hexachlorobutadiene	SV	10		CS	14	0.45			0.45		
Hexachlorocyclopentadiene	SV	10		CS	49						
Hexachloroethane	SV	10		CS		1.9			1.9		
Hydrazine	SV										
Indeno(1,2,3-cd)pyrene	SV	10		CS							
Isophorone	SV	10		CS	1,050						
Naphthalene	SV	10		CS							
Nitrobenzene	SV	10		CS	3.5 (6)						
Nitrophenols	SV										
Nitrosamines	SV										
Nitrosodibutylamine	SV			b		0.0064			0.0064		
Nitrosodiethylamine	SV			b		0.0008			0.0008		
Nitrosodimethylamine	SV			b		0.0014			0.0014		
Nitrosopyrrolidine	SV			b		0.016			0.016		
N-Nitrosodiphenylamine	SV	10		CSb		4.9			4.9		
N-Nitroso-di-n-propylamine	SV	10		CSb							
Pentachlorinated Ethanes	SV			b							
Pentachlorobenzene	SV			b							
Pentachlorophenol	SV	50		CS	6 (6)						
Phenanthrene	SV	10		CS	200						

**TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Segment 4 & 5 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (5)	PQL MDL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	CDH					Acute Value	Chronic Value	Woman Creek	Walnut Creek
Phenol	SV	10	50	CS							
Phthalate Esters	SV			e							
Polynuclear Aromatic Hydrocarbons	SV		10	b		0.0028			0.0028		
Vinyl Chloride	SV	10	2	CV	2						
1,1,1-Trichloroethane	V	5	1	CV	200						
1,1,2,2-Tetrachloroethane	V	5	1	CV		0.17			0.17		
1,1,2-Trichloroethane	V	5	1	CV	28	0.60			0.60		
1,1-Dichloroethane	V	5		CV							
1,1-Dichloroethene	V	5	1	CV	7						
1,2-Dichloroethane	V	5	1	CV	5						
1,2-Dichloroethene (cis)	V		1	a	70						
1,2-Dichloroethene (total)	V	5		CV							
1,2-Dichloroethene (trans)	V	5	1	a	70						
1,2-Dichloropropane	V	5	1	CV	0.56 (6)						
1,3-Dichloropropene (cis)	V	5	1	CV							
1,3-Dichloropropene (trans)	V	5	1	CV							
2-Butanone	V	10		CV							
2-Hexanone	V	10		CV							
4-Methyl-2-pentanone	V	10		CV							
Acetone	V	10		CV							
Acrylonitrile	V		5	c		0.058			0.058		
Benzene	V	5	1	CV	5						
Bromodichloromethane	V	5	1	CV							
Bromoform	V	5	1	CV							
Bromomethane	V	10	1	CV							
Carbon Disulfide	V	5		CV							
Carbon Tetrachloride	V	1		CV	5						
Chlorinated Benzenes	V	10		CV/CS							
Chlorobenzene	V	5	1	CV/CVS	300						

TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Segment 4 & 8 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (5)	PQL MDL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	CDH					Acute Value	Chronic Value	Woman Creek	Walnut Creek
Chloroethane	V	10		CV							
Chloroform	V	5	1	CV	Tot THM <100*	0.19			0.19		
Chloromethane	V	10	1	CV							
Dibromochloromethane	V	5	1	CV							
Dichloroethenes	V		1								
Ethyl Benzene	V	5	1	CV	680						
Ethylene Dibromide	V			d							
Ethylene Oxide	V										
Halomethanes	V				100	0.19			0.19		
Methylene Chloride	V	5	1	CV							
Pyrene	V	10	10	CS							
Styrene	V	5		CV							
Tetrachloroethanes	V	5	1	CV		0.8			0.8		
Tetrachloroethene	V	5	1	CV	10						
Toluene	V	5	1	CV	2,420						
Trichloroethanes	V	5	1	CV							
Trichloroethene	V	5	1	CV	5						
Vinyl Acetate	V	10		CV							
Xylenes (Total)	V	5		CV							

**TABLE A-9. PRELIMINARY CHEMICAL-SPECIFIC TSBs/TBCs (October 30, 1992)+
STREAM SEGMENT (CDH/WQCC) SURFACE WATER QUALITY STANDARDS (ug/l)**

Segment 4 & 8 Stream Classification and Water Quality Standards (b)(4)											
Parameter	Type (6)	PQL MDL		Method (8)	Tables A,B (1)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (5)		Table 2 Radionuclides	
		RFP	CDH					Acute Value	Chronic Value	Woman Creek	Walnut Creek

EXPLANATION OF TABLE

+	= note that values in this table are current as of October 30, 1992
*	= Total trihalomethanes:chloroform, bromoform, bromodichloromethane, dibromochloromethane
CLP	= Contract Laboratory Program
CDH	= Colorado Department of Health
dis	= dissolved
EPA	= Environmental Protection Agency
MDL	= Minimum Detection Limit for radionuclides (pCi/l)
pCi/l	= picocuries per liter
PCB	= polychlorinated biphenyl
PQL	= Practical Quantitation Level
RFP	= Rocky Flats Plant
SS	= species specific
TAL	= Target Analyte List
THM	= Total Trihalomethanes
TIC	= Tentatively Identified Compound
TVS	= Table Value Standard (hardness dependent), see Table III in (a)
ug/l	= micrograms per liter
VOA	= Volatile Organic Analysis
WQCC	= Water Quality Control Commission

(1) In the absence of specific, numeric standards for non-naturally occurring organics, the narrative standard is interpreted as zero with enforcement based on practical quantification levels (PQLs) as defined by CDH/WQCC or EPA

(2) Ammonia, sulfide, chloride, sulfate, copper, iron, manganese, and zinc are 30-day standards, all others are 1-day standards

(3) Lowest value given: dissolved or total recoverable

(4) Segment 5 standards are goals

(5) Includes Table 1: Additional Organic Chemical Standards (chronic only)

(6) Standard is below (more stringent than) PQL, therefore PQL is standard.

(7) MDL for Radium 226 is 0.5; MDL for Radium 228 is 1.0

(a) CDH/WQCC, Colorado Water Quality Standards 3.1.0 (5 CCR 1002-8) 1/15/1974; amended 9/30/1989 (ARAR).
(Environmental Reporter 726:1001-1020:6/1990)

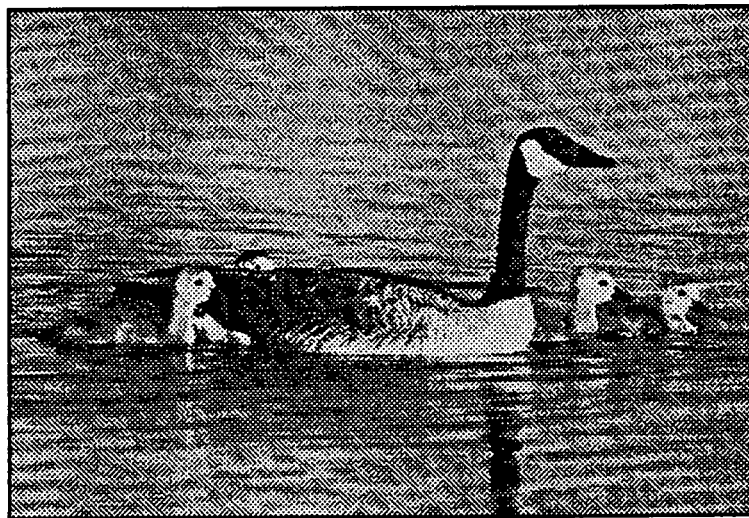
(b) CDH/WQCC, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin,
Smoky Hill River Basin 3.8.0 (5 CCR 1002-8) 4/6/1981; amended 2/15/1990 - Basin-wide standards are ARAR; site-specific standards are TBC

APPENDIX C
WORKPLAN FOR THE CONTROL OF
RADIONUCLIDE LEVELS IN WATER DISCHARGES
FROM ROCKY FLATS PLANT, ANNUAL UPDATE

Appendix C

Annual Update

Workplan for the Control of Radionuclide Levels in Water Discharges from the Rocky Flats Plant



Manual No. 21000-WP-125-01.1



EG&G ROCKY FLATS

P. O. Box 464

Golden, CO 80401

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INTRODUCTION

Appendix C is an annual update to the final Workplan for the Control of Radionuclide Levels in Water Discharges from the Rocky Flats Plant.¹ This annual update was written to mirror the organization of Section 4.0, which described the actual plans and work proposals designed to improve the control of radionuclide levels in discharges of water from RFP. The update describes the accomplishments of the past year in each of the four elements specified in the IAG Statement of Work, Section XII, and outlines current plans for future work, where appropriate. The four elements are:

- Workplan Element #1: Control of Release of Radionuclides
- Workplan Element #2: Assessment of Water Quality
- Workplan Element #3: Analytical Methods
- Workplan Element #4: Treatment Technologies

It is important to note that either budget restrictions and/or implementation of any proposed regulatory changes (e.g., the EPA-proposed removal of the NPDES permit for pond water discharges) could impact future plans and schedules that are described throughout Appendix C.

1.0 WORKPLAN ELEMENT #1: CONTROL OF RELEASE OF RADIONUCLIDES

"The Workplan shall be designed to control the release of radionuclides specified herein. The Workplan will require DOE to sample before any offsite discharges from onsite ponds occur. In accordance with the Agreement in Principle, the Workplan will require that split samples be made available to EPA and CDH . . . DOE will report the results of the sampling and analyses to EPA and the State." (IAG 1991)

1.1 IMPROVING IN-POND WATER MANAGEMENT

The interior Ponds A-1, A-2, B-1, and B-2 are managed as a single unit. Pond levels are controlled by transferring all waters to Pond A-2 for spray evaporation. Spray evaporation operations and interior pond water transfers are closely monitored so there will be no erosion or other harm to the environment in, around, or downstream from the ponds. The placement and operation of the spray evaporation systems will force the spray directly over the pond. Spray evaporation operations are terminated during high winds or precipitation events.

System improvements that were implemented during 1992 include the purchase of two new pumps for installation at Pond A-2 and the Landfill Pond. The Landfill Pond spray nozzles were upgraded to facilitate evaporation, while the Pond A-2 spray nozzles are scheduled to be upgraded in the latter part of calendar year 1993. Future improvement plans include the expansion of spray evaporation to Pond B-2, to enable future management of B-series water independent of the A-series.

¹ The final Workplan for the Control of Radionuclides Levels in Water Discharges from the Rocky Flats Plant, 21000-WP-125 01.1, was issued in January 1992 and received conditional approval from the CDH in March 1992. Sections of the Workplan were revised and reissued in both April and November of 1992. The Workplan is currently awaiting final approval.

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1.2 IMPROVING DAM INTEGRITY

The twelve detention dams associated with the Landfill Pond and the A-, B-, and C-series ponds are routinely monitored by RFP operations and surveillance personnel as part of an integrated dam safety program. This program minimizes the risk of dam failure and the accompanying uncontrolled release of potentially contaminated sediments and large quantities of impounded water. Pond pool elevations are recorded three times per week while dam piezometer levels are generally recorded once per week. The frequency of these readings is increased when heavy precipitation occurs or continually high pool levels occur. Additional assurances of dam integrity are provided by periodic inspections of the embankments and side slopes, especially for cracking or sloughing. Annual inspections of the surface water detention dams are also conducted by the U. S. Army Corps of Engineers, the Office of the State Engineer, and by the Federal Energy Regulatory Commission.

Approximately thirty detention dam best management practices were satisfactorily addressed and implemented, as indicated by a September 30, 1991, Quarterly Dam Safety Report. The report also contained approximately sixty recommendations for repairs and upgrades for specific RFP dams. The implementation of these recommendations is not necessary to meet safety requirements for continued operation, but will allow for enhanced safety and operational effectiveness of the RFP dams.

Evidence of a crack area at Dam B-5 was noticed in August 1991, and has been routinely monitored since. The cracks are precipitation-dependent, which means they either shrink with precipitation or expand during extended dry periods. The cracks were not repaired because there has not been an extended dry period to cause the cracks to reappear. If a crack does reappear, it will be repaired by filling with a sand and bentonite mixture. There has been no evidence observed on the embankment slopes or crest that indicates any sliding or sloughing of the embankment material.

The major projects scheduled for completion in fiscal year 1993 are:

1. Downstream slope stabilization and downstream toe protection for Dam B-1
2. Geotechnical evaluations of A-3, B-1, B-3 and the Landfill dams
3. Geotechnical evaluations of A-4, B-5 and C-2 dams
4. Installation of downstream toe protection on A-1, A-2, B-2, B-3, B-4 and C-1 dams

1.3 REFINING RUNOFF VERSUS POND LEVEL MODELS

Hydrologic modeling of the RFP plantsite is difficult because of the complexity of rainfall patterns, high variability in meteorological patterns at RFP, and continuing facility upgrades (and resulting changes in runoff). Therefore, a computer-based empirical model for predicting the annualized pond levels as a function of normal (expected) precipitation and temperature, runoff factors, and anticipated discharge rates was developed. Two components of this empirical model were completed in 1992: (1) the final Rocky Flats Plant

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Drainage and Flood Control Master Plan² issued in April, and (2) the final Rocky Flats Detention Ponds Capacity Study³, issued in September.

1.4 WEATHER-PROOFING TREATMENT FACILITY

A temporary shelter was constructed at the Pond A-4 water treatment operations to provide inclement weather protection for engineering operations and workers. The Pond A-4 shelter is an 8400 square foot heated enclosure, complete with generator-powered electric lighting and propane-powered radiant heating which maintains a 45° F internal environment. A Certificate of Beneficial Occupancy was issued in September.

A draft procedure for Pond A-4 Shelter Operations has been written and is awaiting final approval. Filter vessels, granular activated carbon (GAC) units, and other ancillary equipment are presently being relocated in the shelter. No additional facility modifications are planned for 1993.

1.5 REUSING/RECYCLING POND C-2 WATER

The Pond C-2 recycle project involves the evaluation, design, and construction of a temporary pipeline to transfer Pond C-2 water back to the plantsite raw water system for reuse in the cooling towers and process applications. Past and present water quality data from Pond C-2 show that the water is more than suitable for these uses. The design would use a "closed loop system" that is isolated by air gaps to prevent potential contact with the domestic water supply system. A comparison of water consumption by the cooling towers with historic inflow to Pond C-2 shows that this project would achieve zero discharge from Pond C-2 in all but the wettest years. Planning for this project is scheduled to continue throughout calendar year 1993.

A replacement of the south half of the pipeline to transfer water from Pond C-2 to Pond B-5 or Pond A-4 was completed in July 1992. This Pond C-2 transfer line is maintained because in emergency situations it is deemed preferable for overall public health protection to transfer the water from Pond C-2 to Pond B-5 or Pond A-4, where it is split-sampled, analyzed, and approved by CDH before discharge, rather than have it either overtop the Pond C-2 dam and spillway or be released directly to the Broomfield Diversion Ditch. All water transferred from Pond C-2 to Pond B-5 or Pond A-4 will be sampled during transfer to meet the same radionuclide requirements as specified by Colorado Water Quality Control Commission (CWQCC) requirements for normal routine pond discharges for radionuclides. The transfer of water is intended as an emergency option and not as a standard practice. To date, this pipeline has never been used.

1.6 SAMPLING AND REPORTING REQUIREMENTS

RFP stormwater runoff and treated waste water effluent are collected in downstream holding ponds, which require sampling and analysis prior to offsite discharge. RFP provides technical water management and water transfer and treatment capabilities to ensure timely discharges of RFP pond water in accordance with all applicable standards for

2 United States Department of Energy prepared by Wright Water Engineers, *Drainage and Flood Control Master Plan for Woman Creek, Walnut Creek, Upper Big Dry Creek, and Rock Creek*, 21000-WP-125 01.1, April 1992

3 United States Department of Energy prepared by Merrick & Company, *Final Summary Report, Detention Pond Capacity Study*, BA 85014 DS, September 1992

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the protection of public health and the environment, such as permit requirements of the National Pollutant Discharge Elimination System (NPDES)⁴ the Agreement in Principle (AIP)⁵, and the Interagency Agreement (IAG)⁶. The AIP and IAG require cooperative sampling, analysis, and water quality assessment to ensure releases are safe and meet applicable standards. RFP continues to coordinate onsite sampling efforts with CDH and other regulatory agencies, through appointed representatives, to ensure that representative predischage and compliance samples and results are available. Although RFP is not required to analyze these split samples on a regular basis, RFP analyzes them to provide confirmatory analyses for regulatory agencies, as needed. The discharge monitoring results are shared with regulatory agencies and interested municipalities at monthly public information exchange meetings.

In addition to the existing NPDES discharge points, the current operational configuration allows transfer of Pond C-2 water to the Broomfield Diversion Ditch, or to Ponds B-5 or A-4, and Pond B-5 water to Pond A-4. Pond A-3 and Pond B-5 waters are normally transferred to Pond A-4 without radionuclide sampling and analysis, since the operational goal of Pond A-4 is to keep it hydrologically isolated for predischage sampling. This is considered adequately safe since the Pond A-4 discharge is dependent upon the Pond A-4 radionuclide results. However, Pond B-5 is sampled for radionuclide analyses during transfer, if heavy precipitation events force the transfer of Pond B-5 to Pond A-4 during Pond A-4 discharge.

Transfer and potential treatment requirements are highly variable because of seasonal weather conditions, soil moisture, and sewage treatment plant flows. Historical data indicate roughly 150 million gallons (Mgal)/year are discharged from RFP (15-20 Mgal are discharged approximately every 6 weeks). Each discharge event (approximately nine per year) requires 10-14 days to complete.

1.7 PROPOSED NEW SAMPLING PROTOCOL

The transition from the original Workplan proposed new sampling protocol to the current sampling protocol was initiated in November 1992. The current sampling protocol is indicated in revised Table 1.1 shown below. The minimum detectable activities (MDA) were lowered by analyzing larger volumes of water and, hence, smaller, tighter, and more sensitive uncertainties were obtained. (These MDAs are below the CWQCC standards promulgated for Segment 4.) The uncertainty associated with the measurement concentration decreased and the confidence in the measurement value increased.

2.0 WORKPLAN ELEMENT #2: ASSESSMENT OF WATER QUALITY

"The Workplan will require that DOE assess the water quality with respect to the recently promulgated CWQCC standards." (IAG 1991)

Analyses of existing sample data indicate low concentrations of radiochemical contaminants in both RFP influent and effluent surface waters. The percentage of samples exceeding the CWQCC standards were similar between RFP pond waters and RFP's raw water source.

⁴ Compliance Agreement in the Matter of NPDES Permit Number C-0001333, Department of Energy, Rocky Flats Plant, Golden Colorado, FFCA-CWA-90-1, NPDES Federal Facility Compliance Agreement, Environmental Protection Agency, March 1991

⁵ Agreement in Principle, State of Colorado and Department of Energy, June 1989

⁶ Rocky Flats Interagency Agreement, Environmental Protection Agency, State of Colorado, Department of Energy, January 1991

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Summary statistics for plutonium-239/240, americium-241, uranium-234, and uranium-238 are presented in Tables 2.2 through 2.5 by surface water location. The summary statistics are included for all data from 1988 through 1991, for the 1988 through 1989 time period, and for the 1990 through 1991 time period. The summary statistics include sample sizes, means, standard deviations, and 85th percentiles.

Histograms for plutonium-239/240, americium-241, uranium-234, and uranium-238 for the six different surface water locations are presented in Figures 2.1 through 2.24. The histograms are a visual representation of a distribution function by using rectangles whose widths represent the range of observed values and whose heights represent the number of observations occurring in each interval. The same frequency scale is used for all of the histograms to facilitate easier comparisons among either radionuclides and/or locations.

Comparison tests based on ranks were run for each radionuclide at six different surface water locations.⁷ The analyses show that differences exist for plutonium-239/240, uranium-234, and uranium-238. No statistical difference was observed for americium-241.

Seasonal variabilities were analyzed among the same six different surface water locations. No seasonal variation was shown for plutonium-239/240 and americium-241, but the data show that a seasonal variability may exist for uranium in all surface water locations except Pond C-1 and RFP's raw water supply. The highest concentration of uranium appeared in April, and the lowest concentration in July/August.

Measured concentrations for plutonium-239/240 and americium-241 are near the MDA for the currently used technology. Examination of the data show nearly equal numbers of concentrations above and below zero. Uncertainty measurements should always be displayed with the individual measurements to portray the variability that exists in the sampling and analytical methodology. Measured concentrations do not represent the actual amount of material present in the sample, but range somewhere between the lower and upper limits of the measurement plus the uncertainty. Current CWQCC standards are based on normal statistical distribution of the data. These standards were set to have some probability of the population exceed them even if no difference exists. Caution should be used when comparing single-point measurements to the standards. Data should be analyzed as a population and not individually.

3.0 WORKPLAN ELEMENT #3: ANALYTICAL METHODS

3.1 GENERAL CONSIDERATIONS

The Workplan will establish validated methods as identified by EPA and the State, including as appropriate, the methods delineated in 40 CFR 141.25, to determine concentrations of the parameters below. Parameters for which no validated standard analytical method exists, DOE will propose an analytical method for EPA and State approval." (IAG 1991)

This section describes the improvements that have been made in radionuclide analytical capability. Improvement areas include: MDA, RFP operating and analytical procedures, analytical detection comparisons, and real-time monitoring studies.

⁷ Hettmansperger, T. P., *Statistical Inference Based on Ranks*, Wiley, New York, 1984

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3.2 IMPROVING ANALYTICAL METHODS AND PERFORMANCE

The original Workplan described several approaches to improve analytical performance: improving detection limits, increasing analytical sensitivity, improving chemical separations, increasing sample volumes, and increasing counting times. The simplest approach, increasing sample volumes, was evaluated first.

The original Workplan stated that MDAs for recent historical radiometric data from RFP approximated a 0.08 pCi/L level for the typical one liter sample. Following a transition period which started in November 1991, the sample volumes for plutonium and americium were routinely increased to four liters (for non-discharge samples) or seven liters (for discharge samples) as a result of this volume increase. The sample MDAs and associated sample errors were significantly reduced. (See Table 1.1.)

**Table 1.1
Current Sampling Schedule for Pond A-4**

Week Number	Sampling Scheme	Analytical Volume	Approximate MDA For Pu/Am
Week 1	1 In-pond Depth Composite Sample	4 liter	0.02 pCi/L*
Week 2	1 In-pond Depth Composite Sample	4 liter	0.02 pCi/L
Week 3	2 In-pond Depth Composited (CDH splits)	4 liter	0.02 pCi/L
Week 4	1 In-pond Depth Composited	4 liter	0.02 pCi/L
Week 5	1 In-pond Depth Composited	4 liter	0.02 pCi/L
Week 6	7 Daily Discharge Samples	7 liter	0.01 pCi/L
Week 7	7 Daily Discharge Samples	7 liter	0.01 pCi/L

* pCi/L = Picocuries per liter (10^{-9} Curies)

3.2.1 Los Alamos National Laboratory Analytical Comparison

The Los Alamos National Laboratory (LANL) was contracted during fiscal year 1992 to obtain analytical measurements of and establish a database for selected actinides at low

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Table 2.1
Summary Statistics
Plutonium-239/240

	<u>Location</u>	<u>124 Raw</u>	<u>Pond A-4</u>	<u>Pond B-5</u>	<u>Pond C-1</u>	<u>Pond C-2</u>	<u>Walnut</u>
ALL DATA	Sample Size	47	138	68	177	42	162
	Mean	0.006	0.004	0.013	0.014	0.029	0.007
	Std. Dev.	0.036	0.025	0.049	0.027	0.031	0.021
	85th %	0.024	0.021	0.026	0.033	0.054	0.024
1988-1989	Sample Size	23	26	36	75	11	53
	Mean	0.005	0.011	0.020	0.013	0.053	0.014
	Std. Dev.	0.021	0.027	0.061	0.022	0.040	0.023
	85th %	0.027	0.029	0.032	0.030	0.100	0.039
1990-1991	Sample Size	24	112	32	102	31	109
	Mean	0.008	0.003	0.006	0.015	0.020	0.004
	Std. Dev.	0.047	0.025	0.028	0.030	0.021	0.018
	85th %	0.017	0.018	0.017	0.034	0.040	0.019

Table 2.2
Summary Statistics
Americium-241

	<u>Location</u>	<u>124 Raw</u>	<u>Pond A-4</u>	<u>Pond B-5</u>	<u>Pond C-1</u>	<u>Pond C-2</u>	<u>Walnut</u>
ALL DATA	Sample Size	47	135	68	172	40	163
	Mean	0.007	0.009	0.015	0.008	0.017	0.010
	Std. Dev.	0.024	0.025	0.026	0.017	0.034	0.023
	85th %	0.020	0.027	0.036	0.015	0.044	0.027
1988-1989	Sample Size	23	26	36	74	11	53
	Mean	0.005	0.012	0.020	0.008	0.043	0.014
	Std. Dev.	0.021	0.028	0.029	0.016	0.050	0.024
	85th %	0.029	0.027	0.038	0.018	0.117	0.026
1990-1991	Sample Size	24	109	32	98	29	110
	Mean	0.010	0.009	0.008	0.007	0.007	0.009
	Std. Dev.	0.026	0.025	0.022	0.018	0.019	0.022
	85th %	0.020	0.027	0.028	0.014	0.022	0.030

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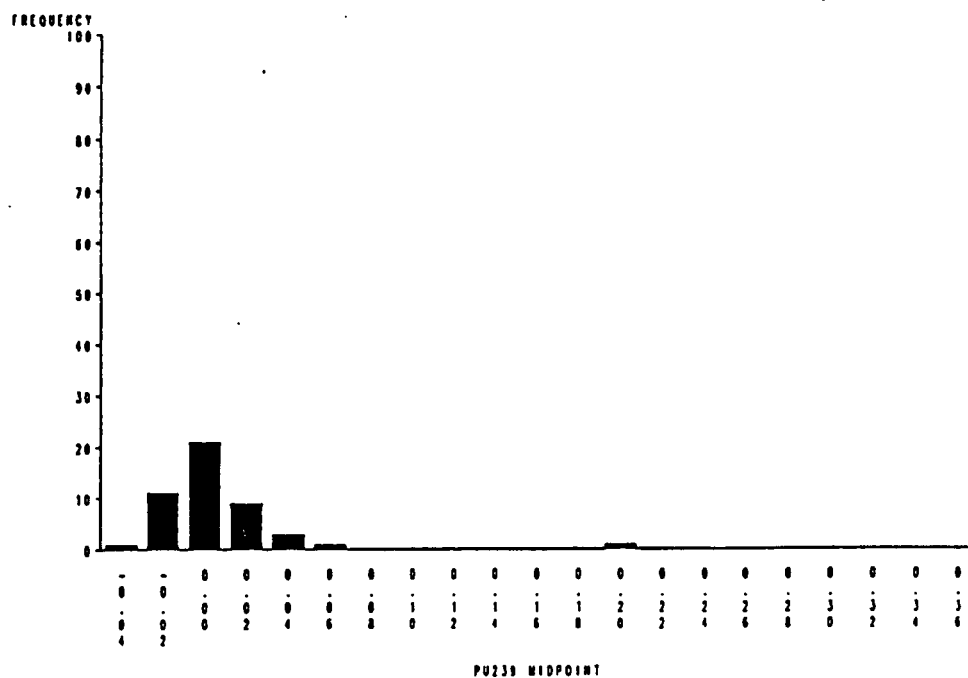
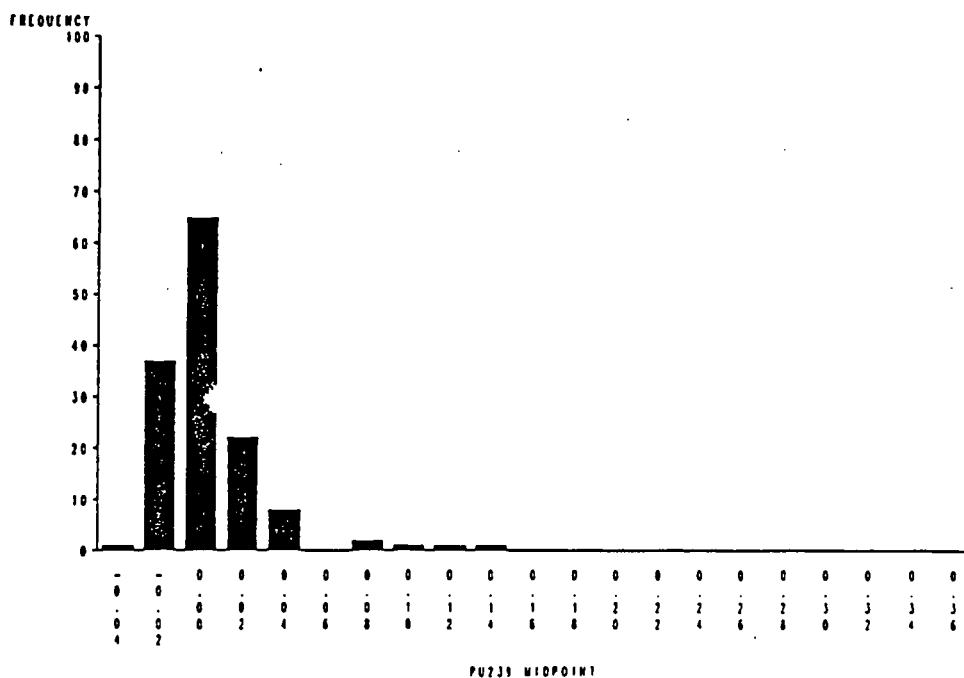
Table 2.3
Summary Statistics
Uranium-233/234

	<u>Location</u>	<u>124 Raw</u>	<u>Pond A-4</u>	<u>Pond B-5</u>	<u>Pond C-1</u>	<u>Pond C-2</u>	<u>Walnut</u>
ALL DATA	Sample Size	47	138	68	177	40	164
1988-1990	Mean	0.593	1.215	1.543	0.710	1.149	1.459
	Std. Dev.	0.556	0.889	0.967	0.590	0.550	1.062
	85th %	1.051	2.129	2.483	1.066	1.911	2.391
1988-1989	Sample Size	23	26	36	75	10	53
	Mean	0.705	2.147	1.767	0.768	0.790	2.253
	Std. Dev.	0.673	0.707	0.919	0.665	0.487	1.333
	85th %	1.534	3.300	2.650	1.237	1.445	3.548
1990-1991	Sample Size	24	112	32	102	30	111
	Mean	0.486	0.998	1.290	0.667	1.269	1.080
	Std. Dev.	0.402	0.783	0.971	0.528	0.523	0.617
	85th %	0.788	1.782	2.433	0.989	1.978	1.909

Table 2.4
Summary Statistics
Uranium-238

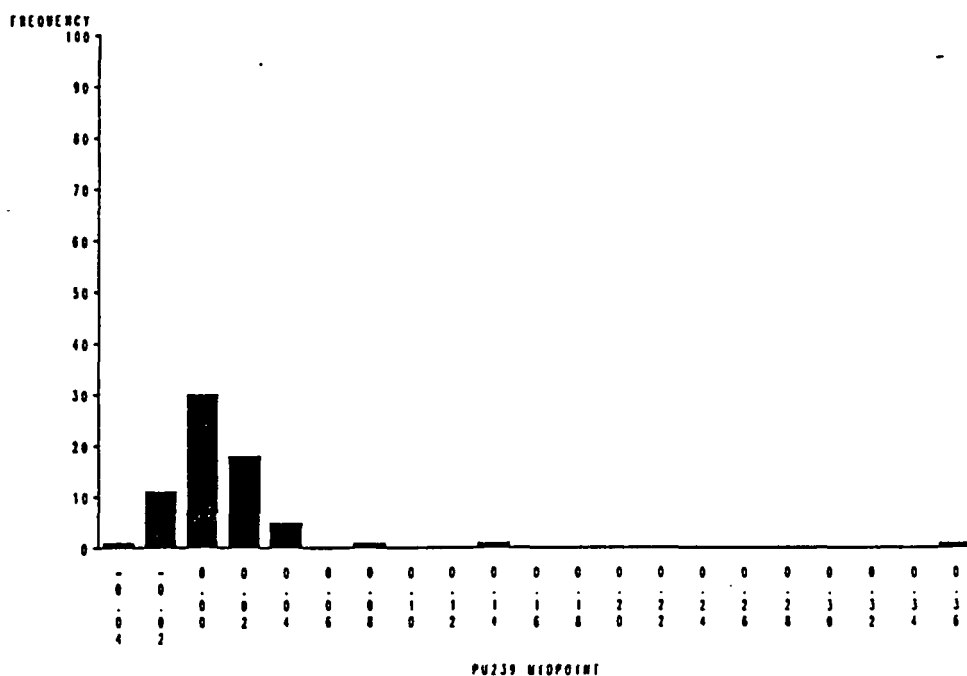
	<u>Location</u>	<u>124 Raw</u>	<u>Pond A-4</u>	<u>Pond B-5</u>	<u>Pond C-1</u>	<u>Pond C-2</u>	<u>Walnut</u>
ALL DATA	Sample Size	47	138	68	176	40	164
1988-1990	Mean	0.498	1.599	1.337	0.489	1.441	1.474
	Std. Dev.	0.456	1.370	0.785	0.280	0.743	1.066
	85th %	0.778	3.055	2.176	0.796	2.422	2.402
1988-1989	Sample Size	23	26	36	74	10	53
	Mean	0.589	3.573	1.504	0.532	1.086	2.311
	Std. Dev.	0.573	1.388	0.702	0.339	0.792	1.316
	85th %	1.107	5.131	2.176	0.972	2.167	3.249
1990-1991	Sample Size	24	112	32	102	30	111
	Mean	0.412	1.140	1.150	0.457	1.560	1.074
	Std. Dev.	0.293	0.870	0.841	0.225	0.700	0.606
	85th %	0.730	2.018	2.177	0.721	2.506	1.813

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PLUTONIUM 239/240 CONCENTRATIONFor Samples Collected Since 1/1/88
LOCATION=124 Box**PLUTONIUM 239/240 CONCENTRATION**For Samples Collected Since 1/1/88
LOCATION=Pond A-4

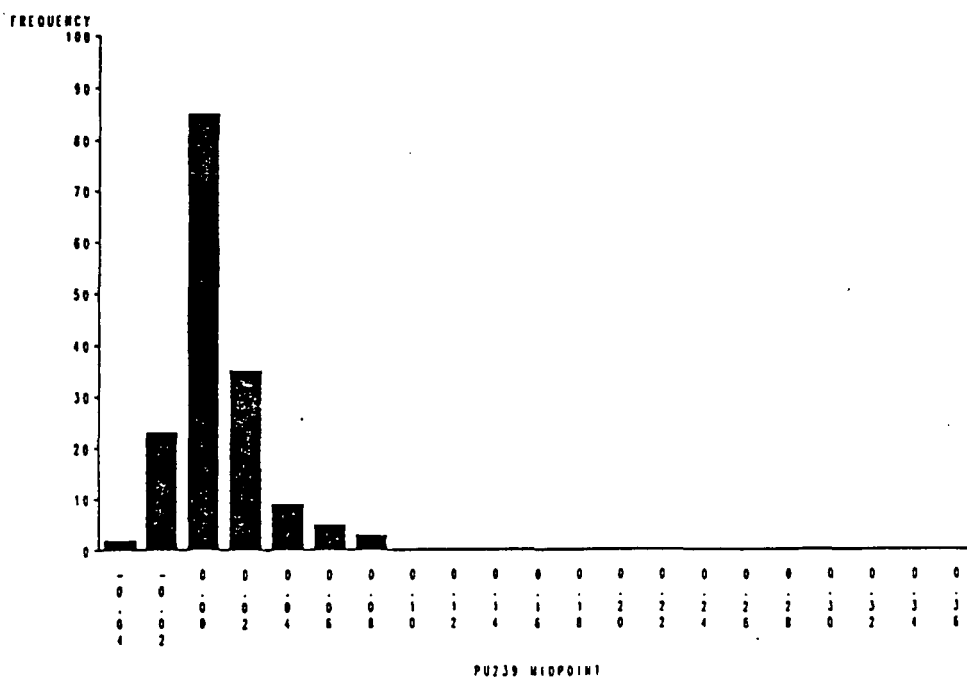
PLUTONIUM 239/240 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION=Peed B-5



PLUTONIUM 239/240 CONCENTRATION

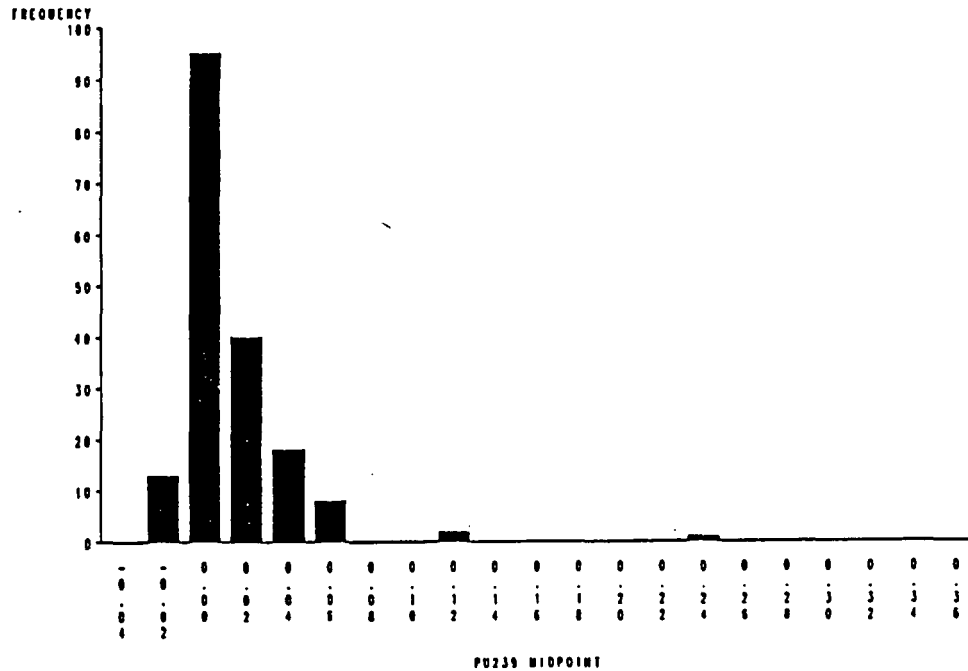
For Samples Collected Since 1/1/88
LOCATION=Valent/Indiana



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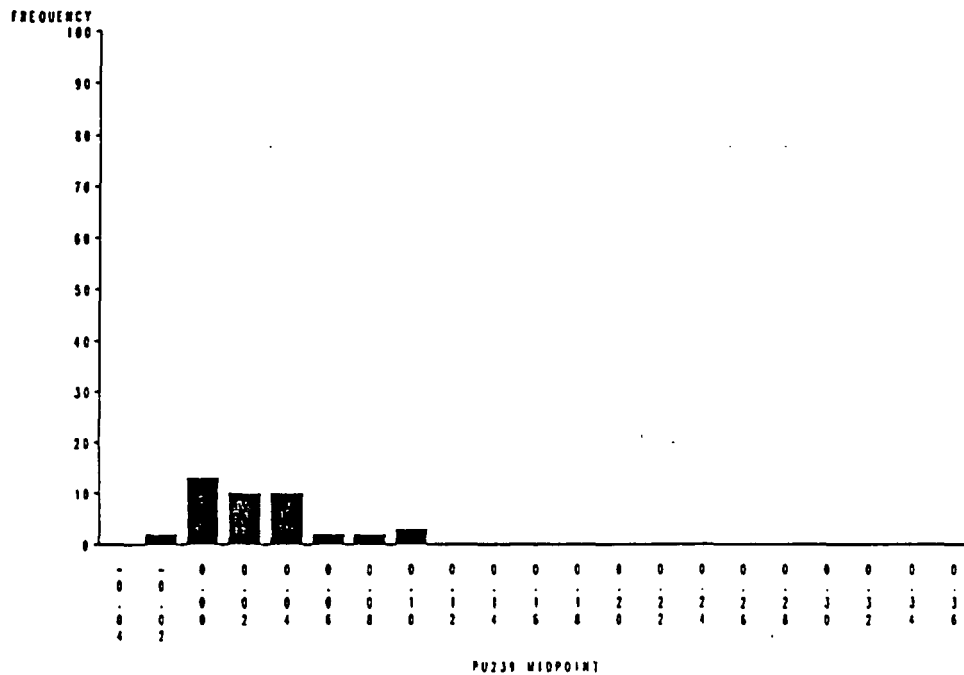
PLUTONIUM 239/240 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION=Pool C-1



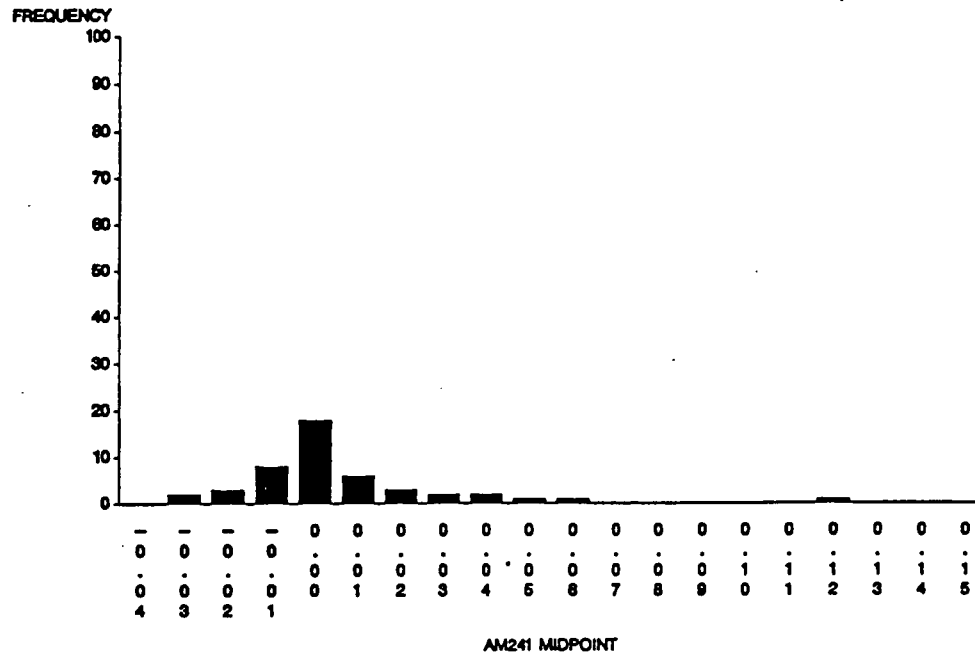
PLUTONIUM 239/240 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION=Pool C-2

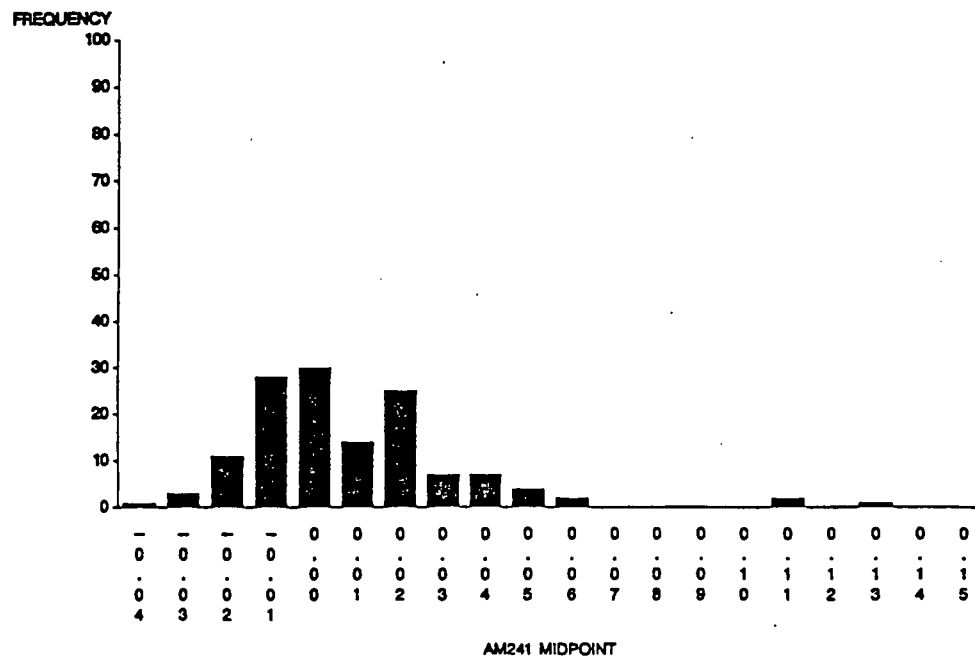


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AMERICIUM 241 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = 124 Raw

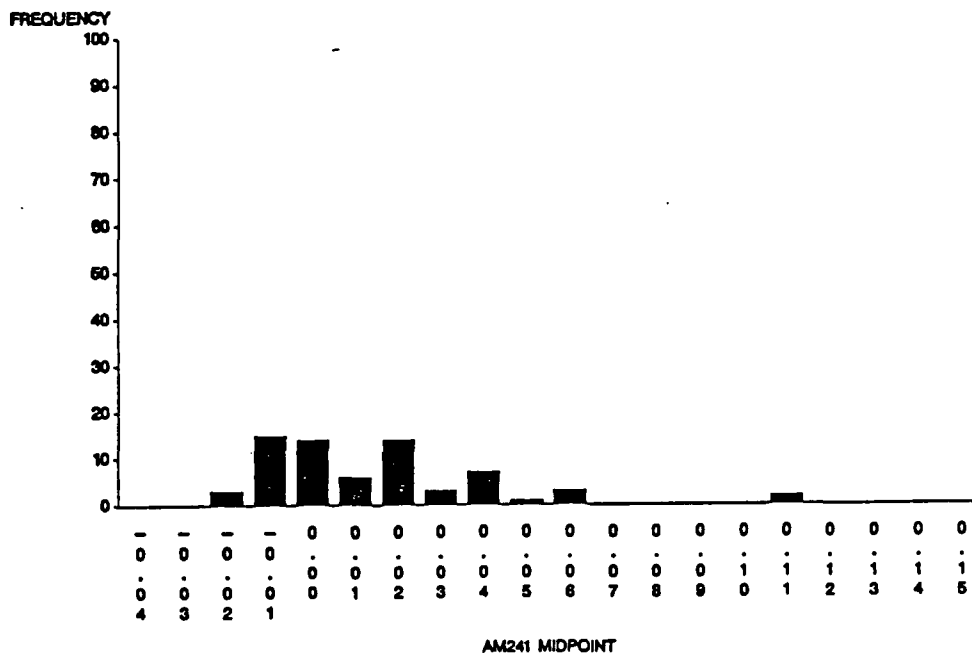
AMERICIUM 241 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Pond A-4

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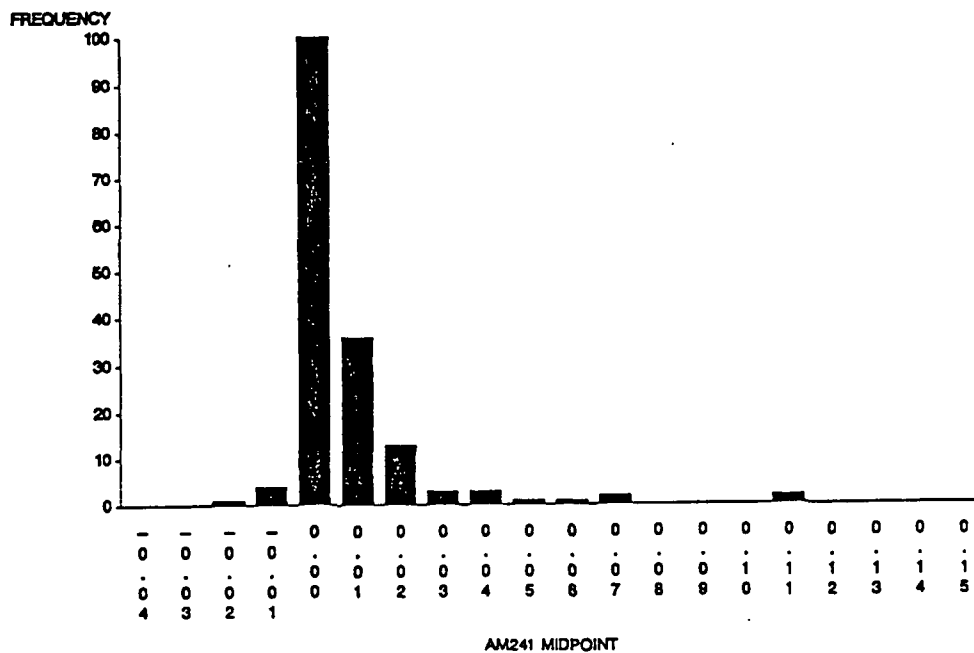
AMERICIUM 241 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION - Pond B-5

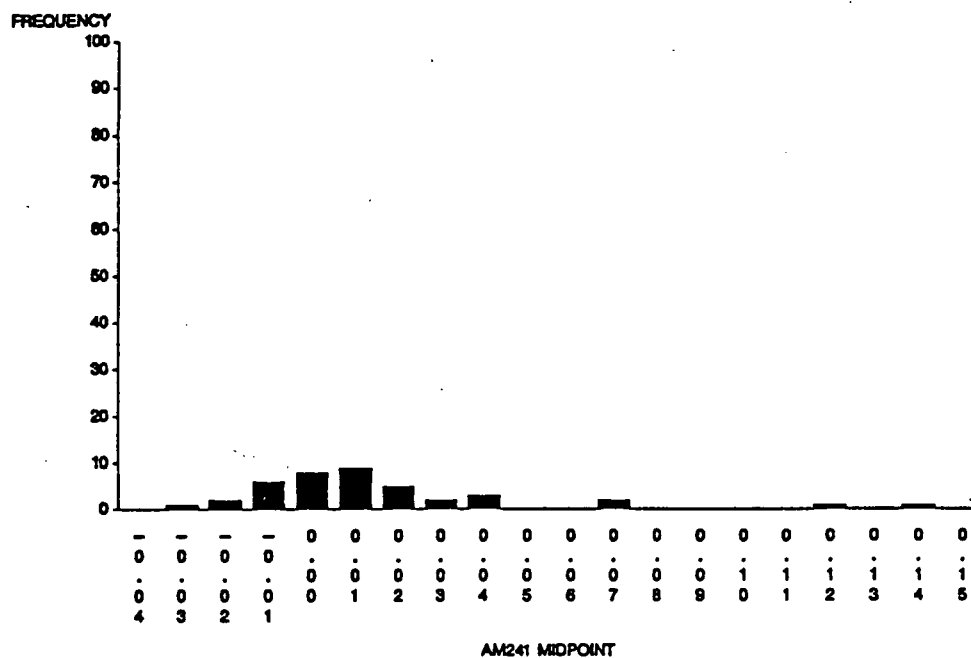


AMERICIUM 241 CONCENTRATION

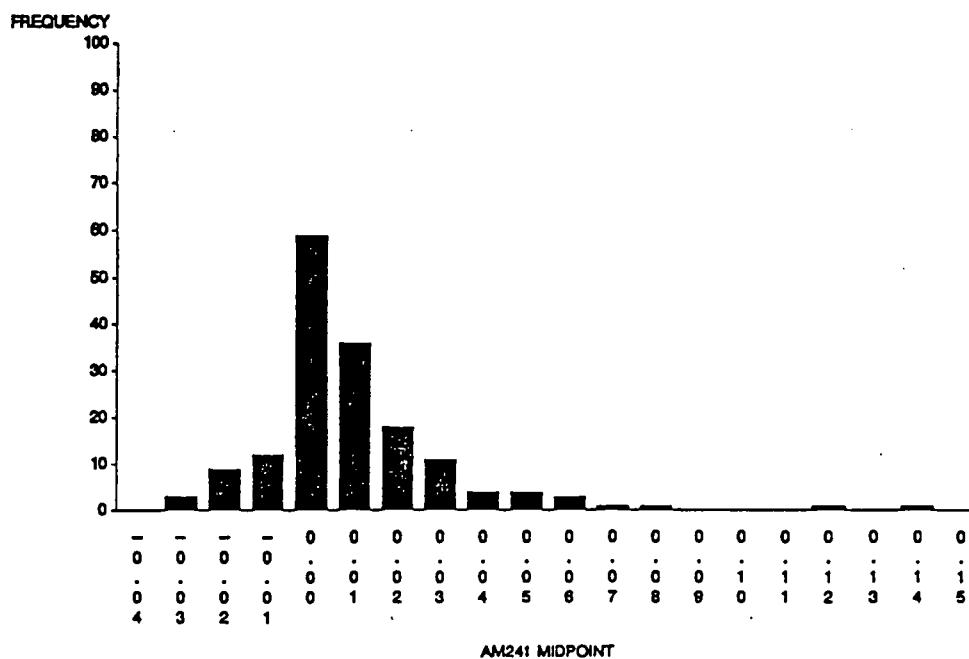
For Samples Collected Since 1/1/88
LOCATION - Pond C-1



AMERICIUM 241 CONCENTRATION

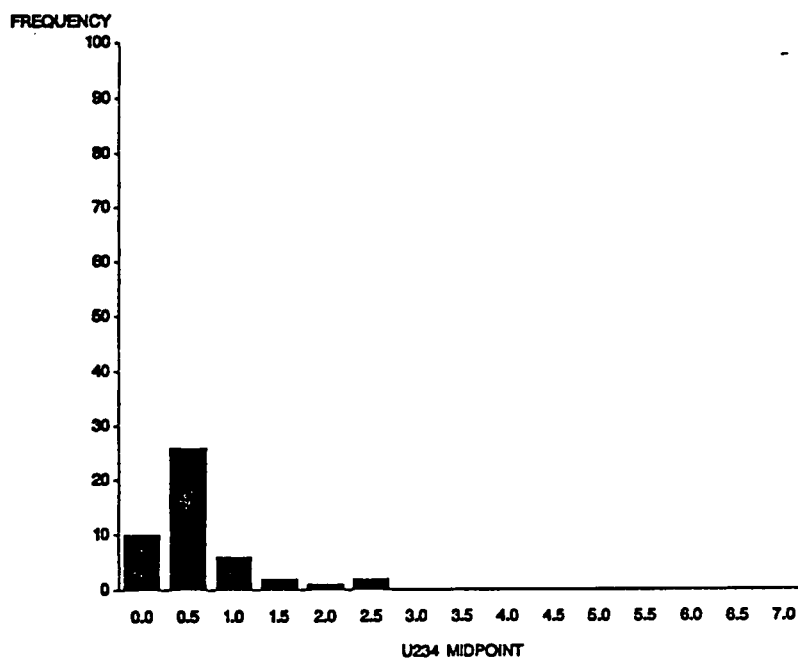
For Samples Collected Since 1/1/88
LOCATION = Pond C-2

AMERICIUM 241 CONCENTRATION

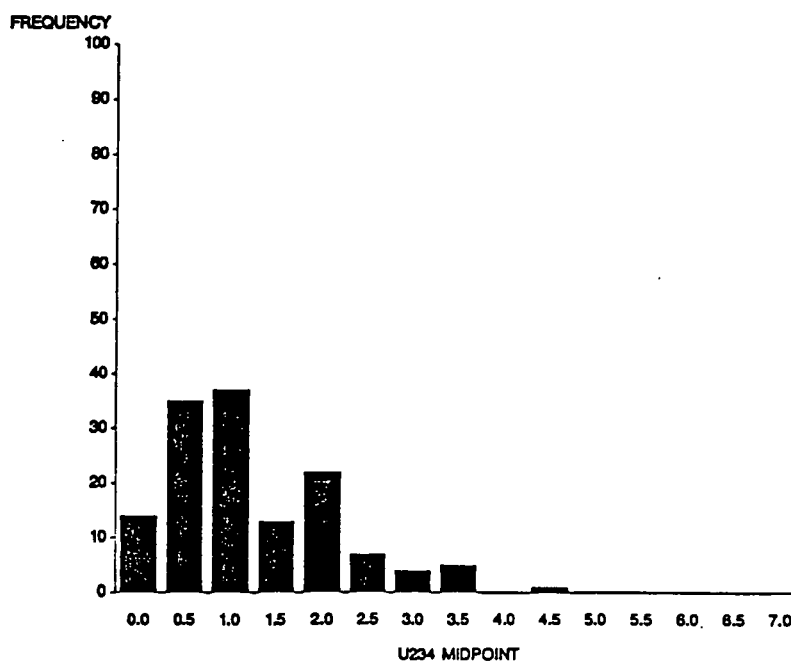
For Samples Collected Since 1/1/88
LOCATION = Walnut/Indiana

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URANIUM 234 CONCENTRATION

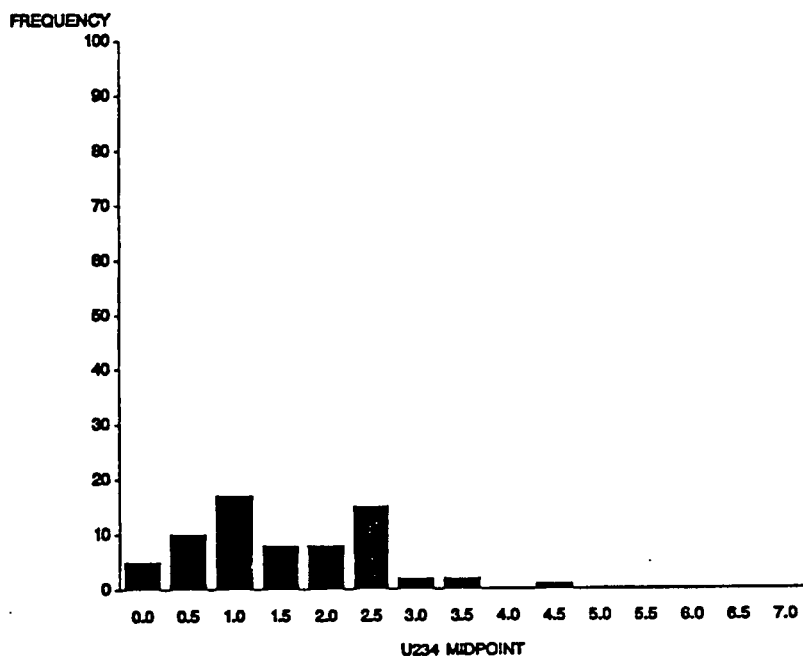
For Samples Collected Since 1/1/88
LOCATION-124 Raw

URANIUM 234 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Pond A-4

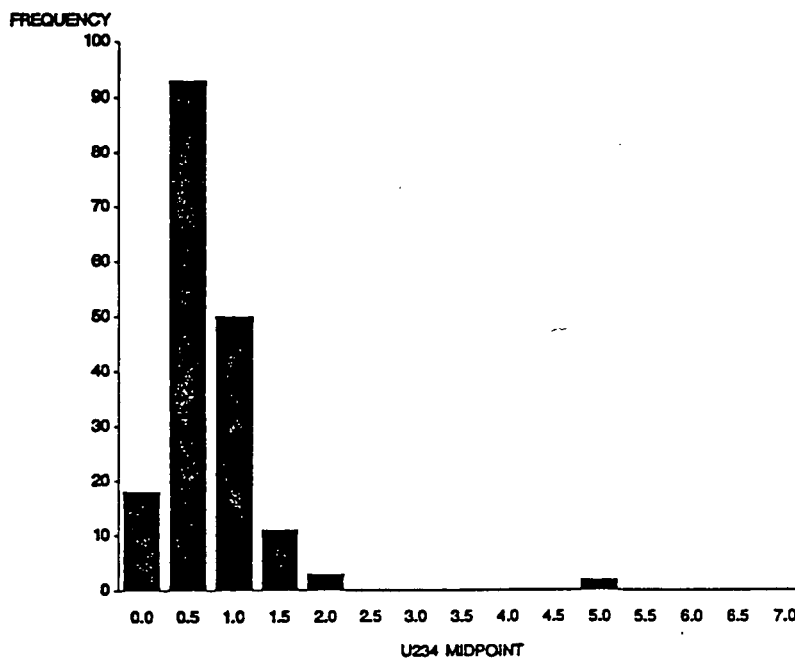
URANIUM 234 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Pond B-5



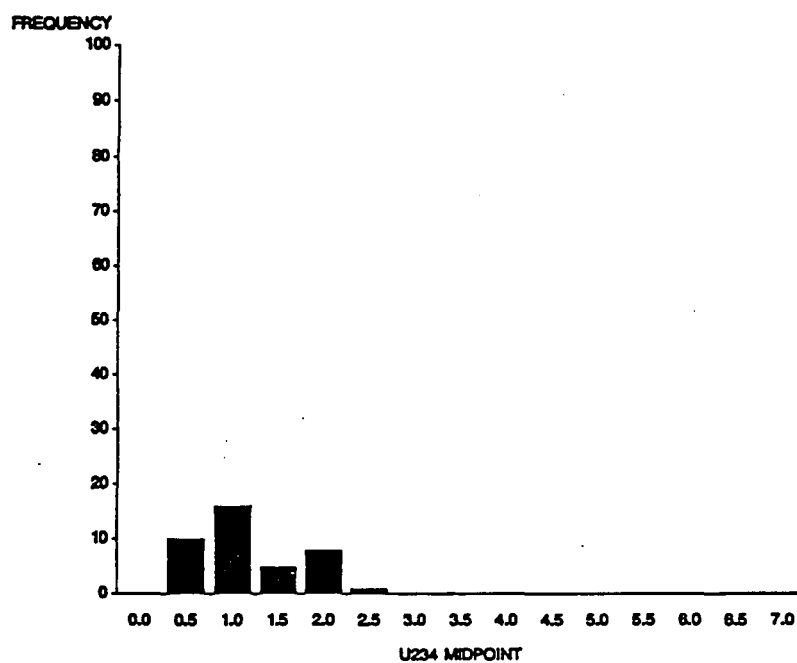
URANIUM 234 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Pond C-1



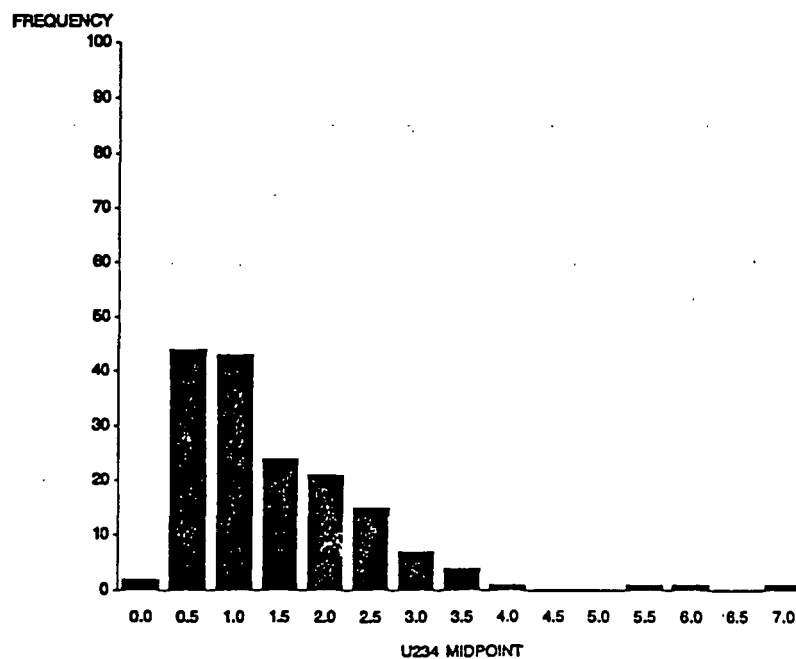
URANIUM 234 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Pond C-2



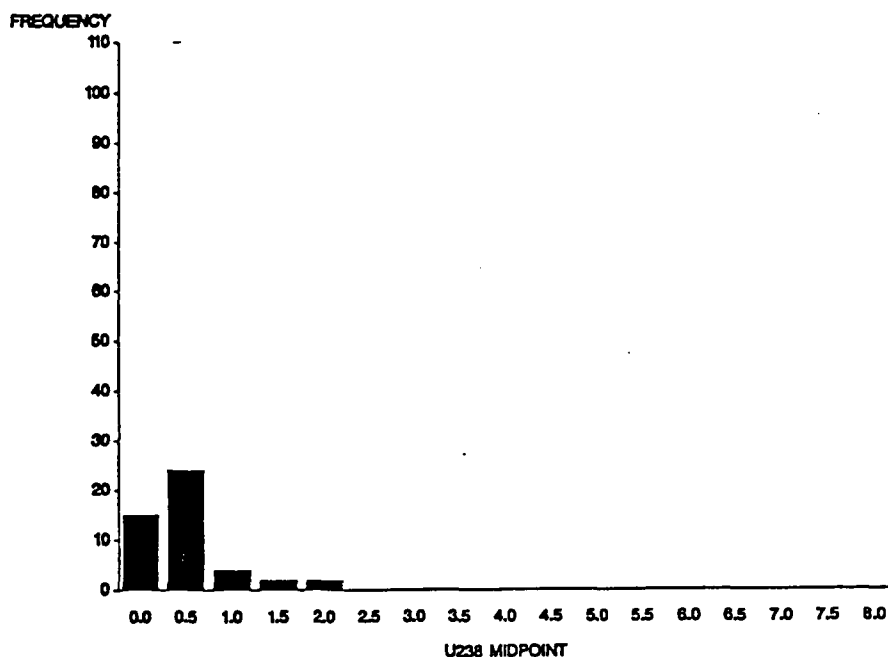
URANIUM 234 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Walnut/Indiana



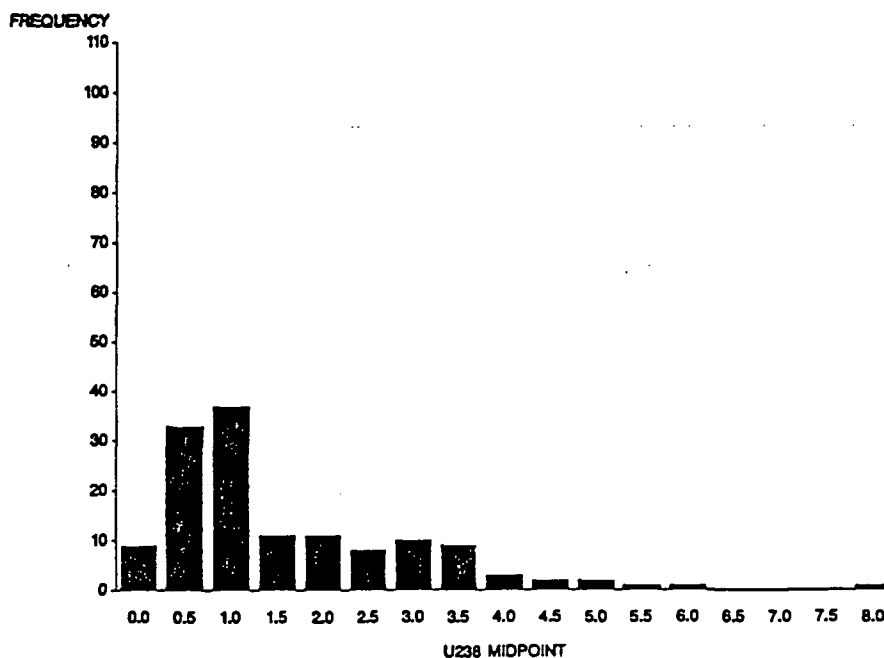
URANIUM 238 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = 124 Raw



URANIUM 238 CONCENTRATION

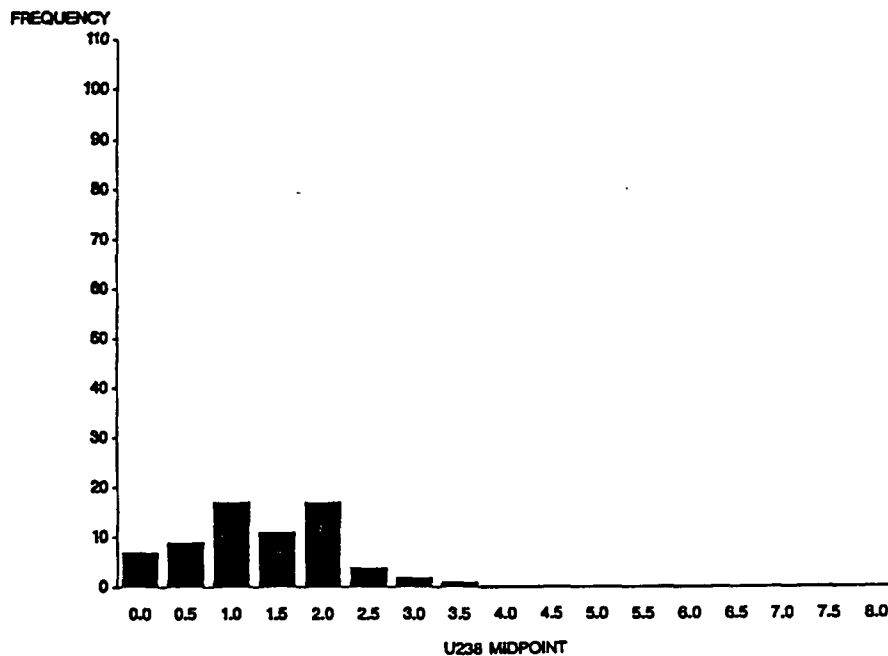
For Samples Collected Since 1/1/88
LOCATION = Pond A-4



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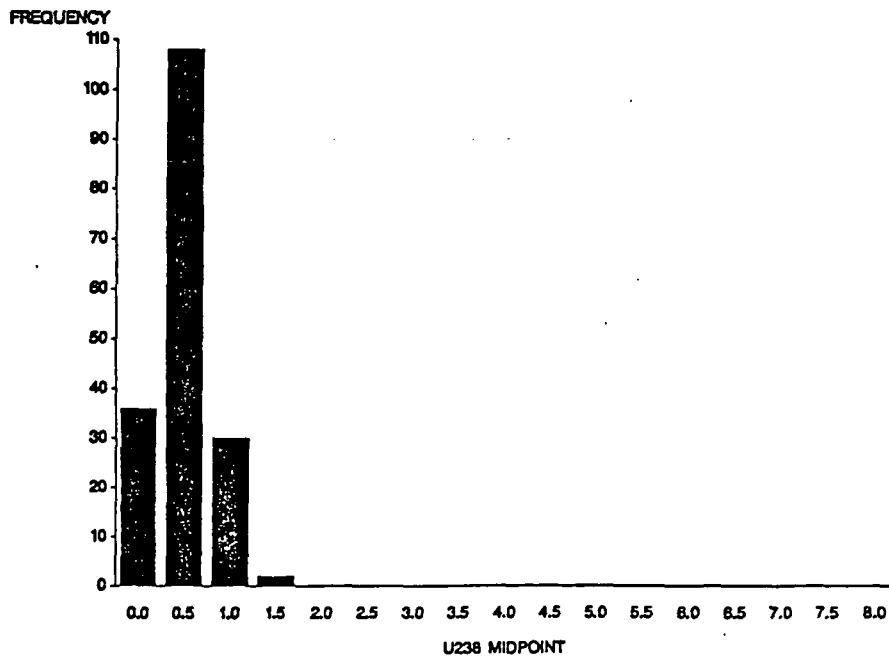
URANIUM 238 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Pond B-5



URANIUM 238 CONCENTRATION

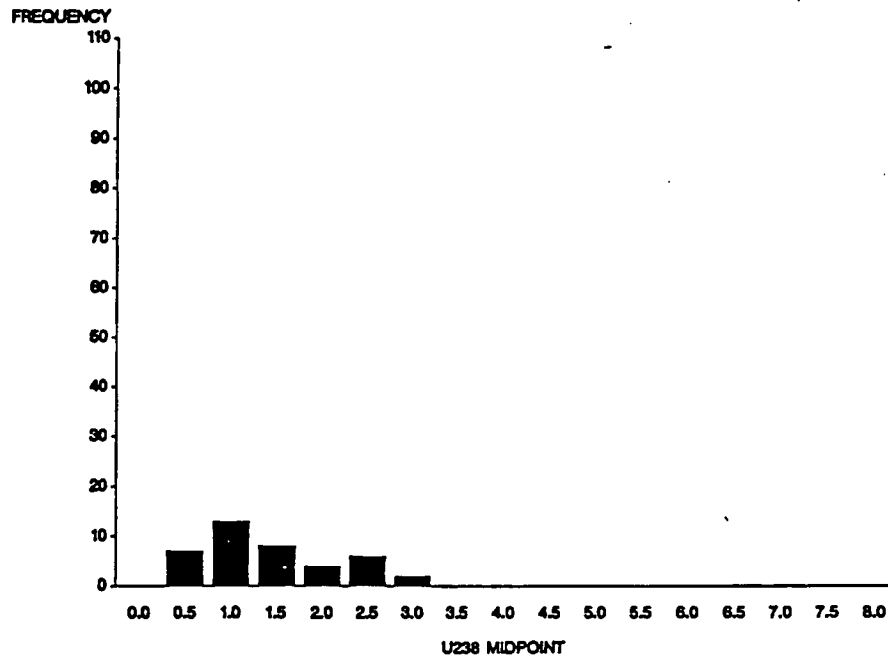
For Samples Collected Since 1/1/88
LOCATION = Pond C-1



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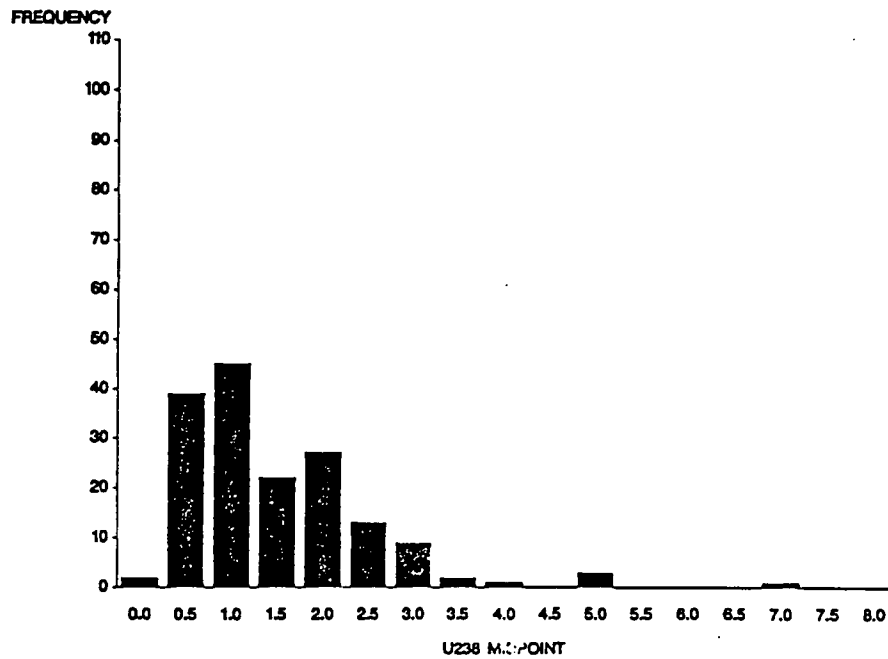
URANIUM 238 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Pond C-2



URANIUM 238 CONCENTRATION

For Samples Collected Since 1/1/88
LOCATION = Walnut/Indiana



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concentration levels (0.05 - 0.003 pCi/L).⁸ Studies at LANL have demonstrated that isotope dilution mass spectrometry (IDMS) can achieve 0.003 pCi/L sensitivity for plutonium and americium.

As a preliminary experiment, triplicate analyses of Pond C-2 samples were run along with processing blanks to determine homogeneity. LANL concluded that the results from this set of samples only, indicated the inhomogeneity observed in Pond C-2 was real because the coefficient of variability (CV) among the triplicate samples was 16 percent while the processing blanks displayed a CV of only 0.8 percent.

General observations concluded that plutonium can be measured at the 0.05 pCi/L level by either alpha spectroscopy or thermal ionization mass spectrometry (TIMS). The analytical uncertainty (95 percent confidence level) associated with alpha spectroscopy measurements of 0.05 pCi/L levels is approximately 30 percent. Alpha spectroscopy is an excellent screening tool that always finds plutonium present in a sample once the limit of detection is exceeded. However, if extraneous radionuclides emitting alpha particles with energies in the range from 4.8 - 5.6 million electron volts (MeV) are present in the sample submitted for counting, alpha spectroscopy will report anomalously high plutonium concentrations. Alpha spectroscopy cannot distinguish plutonium-240 from plutonium-239, so cannot be used for isotopic "fingerprinting" of plutonium, but can be used to measure plutonium-238 concentrations in environmental samples.

TIMS measurement techniques are capable of accurate and consistent isotopic plutonium analyses at lower levels than is possible with alpha spectroscopy. The lowest limit of detection (LLD) obtainable by TIMS is at least 100 times lower than that obtained by alpha spectroscopy. However, TIMS is not suitable for environmental plutonium-238 measurements because trace quantities of uranium-238 are always present in environmental samples, chemical reagents and the TIMS' source and filament materials. This uranium-238 can cause an isobaric interference that biases the plutonium-238 results. An analysis of ten of the eleven sets of waters from Pond C-2 that were measured by alpha spectrometry and TIMS were not significantly different at the 95 percent confidence interval.

A future contract with LANL will continue to evaluate methods to improve and refine the methods used to provide the analytical data. Specifically, to decrease the time required for radionuclide analyses and to improve the lower level of detection for radionuclides. This measurement technology is required to support the characterization of the radionuclides in the detention ponds, drainage flows, and sedimentation zones at RFP.

3.2.2 Developing Concurrence on Analytical Methods

PredischARGE pond water samples are routinely analyzed for radionuclides by both RFP and CDH. The laboratories of both RFP and CDH now have the capability to detect radionuclides at MDAs below the existing standards, though different analytical methodologies are used. This allows the CDH laboratory to independently verify the RFP laboratory analytical capability and obviates the need for a series of formal technical discussions to resolve technical issues and arrive at concurrence on analytical methodology, radiometric measurements, and data interpretation.

⁸ G. W. Knobeloch, V. M. Armijo and D. W. Eford, *Separation of Uranium and Plutonium from Underground Nuclear Debris for Mass Spectrometric Analyses*, in *Collected Radiochemical and Geochemical Procedures*, J. Kleingberg Ed., Los Alamos National Laboratory report LA-1721, 5th ed., 1990

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3.3 GOALS AND TARGETS FOR ANALYTICAL IMPROVEMENTS

Four analytical goals were identified in the original Workplan. These goals serve as targets towards which future improvements would aim. An anticipated timeframe to reach these targets was given as three to five years. The original targets and the progress towards them are stated as follows:

1. *"To determine compliance and acceptability of continuing discharges - develop analytical protocol having plutonium and americium MDA of 20 fempto Curie per liter, 10-15 (fCi/L) or better with a turnaround time of 1 day or less."* The MDA portion of this task would be theoretically possible if a starting volume of water of approximately 100 liters could be reduced via a rapid scavenger technology. At this time, the technology does not exist.
2. *"To demonstrate treatment methods to remove residual radionuclides - develop analytical protocol having plutonium and americium MDA of 3 fCi/L with turnaround time of 10-14 days."* The Los Alamos National Laboratory has demonstrated that these results are possible only at a laboratory bench-scale level under tightly controlled conditions within the stated timeframe.
3. *"To provide real-time radiometric measurements - develop detector with LLD of 7.5 pCi/L total alpha in effluent water."* At this time, commercial real-time radiometric measurement capability does not exist at any level. However, significant progress has been made during the past year to develop the framework for potential applications of real-time measurement. Section 3.5 of this appendix provides additional details.
4. *"To establish better understanding of environmental Pu - define Pu occurrence and characteristics in RFP pond water."* Los Alamos National Laboratory has conducted research activities to define and characterize environmental plutonium occurrence at RFP. Section 4.2 of this appendix provides additional details.

3.4 PROPOSED REAL-TIME MONITORING METHODOLOGY

3.4.1 Particle Analysis System

Process improvements are being made to RFP existing treatment operations by utilizing physical separations in order to avoid chemical treatment. For example, filtration processes may be improved by applying real-time monitoring and control methods to particle counting technologies. Particle counting technology simultaneously sizes and enumerates individual particles. Particle count and size distribution data are applicable to monitor many types of water filtration system to assess the effective removal of micron-sized particulate material. This attribute has broad applicability for use in water treatment process control, design, and selection, as well as for establishing drinking water quality criteria.

RFP is investigating the potential to use commercial particle counter equipment as a real-time water quality indicator for particles in the 1 to 150 micron particle size range. The future applications and proposed uses for the Particle Analysis System (PAS) include: the Pond Water Treatment System and discharges, the drinking Water Treatment Plant at Building 124, and the Operable Units (OU) OU1 and OU2.

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A portable PAS was assembled, calibrated, and tested during calendar year 1992. Batch sampling was performed on various water systems to verify the basic operation of the PAS and batch sampling will continue to be used before applying the PAS on-line to a specific water filtration system. One person was factory-trained for calibration, operation, repair and complete maintenance of the PAS.

The PAS is currently being tested on-line at the Operable Unit 2 (OU2) Memtek® membrane system to determine the counts, distributions, and filter removal efficiencies in the 1 to 150 micron range. A progress report on this PAS application is anticipated to be complete by the latter part of calendar year 1993.

3.4.2 Remote Surface Water Monitoring

RFP has developed and installed a unique, real-time surface water remote sensing and reporting system consisting of commercially available sensors and instrumentation based on the best available technologies of microelectronics and environmental sciences.⁹ The use of real-time monitoring and measurement allows surveillance of flows and certain water quality parameters during routine conditions and during adverse weather or storm events. Acquired data are used for regulatory reporting (e.g., Discharge Monitoring Report and daily reporting requirements), status monitoring of water discharges, and providing real-time monitoring and decision-making information during storm events.

The Remote Surface Water System consists of three major components: field sensors, remote networks, and a real-time Graphical User Interface (RTGUI). There are field sensors located at 25 stations (12 for air monitoring and 13 for surface water monitoring) in unimproved areas of the RFP, including holding ponds and offsite discharge points. The field sensors measure flow with Parshall flumes equipped with ISCO® bubblers and Drexelbrook® conductance meters. Real-time water quality parameters such as temperature, dissolved oxygen, percent saturation, specific conductivity, pH, salinity, and reduction-oxidation are measured with a Hydrolab® H₂O probe. A Hach® real-time turbidity sensor and a Druck® pressure transducer were also installed. The field sensors are completely self-contained and powered by solar panels.

Two remote networks are the link between the field sensors and a single centralized RTGUI. These networks communicate through radio transmission, phone lines, and a Wide Area Network (WAN). The RTGUI is a Genesis software package installed on a personal computer which can display real-time and historical raw and computed data as well as real-time graphical and text animation of the data. Each station performs its own calculations, determines when to send results, and then double-checks itself to verify that the information has been properly relayed. If the system is busy, each station can store the data for later transmission or retrieval.

Future plans include an expansion of the field sensor network, the improvement of network communications, and the evaluation of on-line real-time monitoring for low level radionuclide radio-based stations to measure groundwater depth.

⁹ D. R. Baxter and W. L. Goodwin, *Remote Surface Water Monitoring*, SWD-002-93, EG&G Rocky Flats, Inc., February 1993

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4.0 WORKPLAN ELEMENT #4: TREATMENT EVALUATIONS AND PROPOSALS

4.1 IMPROVING TREATMENT

"The Workplan will require DOE to identify potential treatment technologies to be utilized in the event that water quality for the terminal ponds exceeds the State standards. If no existing technologies adequate to achieve the standards are identified, DOE will use reasonable efforts to develop and implement such technologies. If achieving water quality that does not exceed the standards requires additional treatment or development of additional technologies, the parties agree to negotiate appropriate modifications to the Workplan, including schedules." (IAG 1991)

The Workplan identified several potentially applicable treatment technologies which are included under BAT. Some of these are being evaluated under the Superfund Innovative Technology Evaluation (SITE) program, the Emerging Technology Evaluation Program (ETEP) and priority Operable Unit (OU) programs at RFP. Monitoring of these programs continued over the year and in addition, several bench scale and pilot scale tests were run to evaluate potentially applicable treatment processes and equipment items which were not otherwise being evaluated. Characterization studies were continued in 1992 to increase understanding of radionuclide chemistry in terms of solubility, complexation and sorption properties. An understanding of these properties is used in evaluating candidate treatment processes.

4.1.1 Filtration Equipment

The combination of current pond operations requiring long holding times and an available nutrient supply can lead to algal growth in some of the ponds during the summer. Algae increase the suspended solids in the water and clog the filters and granular activated carbon (GAC) used to treat the water, which requires frequent filter bag changing rates and subsequent frequent backwashing of the GAC. A pilot-scale test program was therefore conducted to evaluate the potential of a selected commercial microstrainer, to remove algae.¹⁰

Microstrainer testing was conducted over three weeks at the three final ponds using various pore sizes and measurement effectiveness parameters. It was concluded that microstraining is not suitable treatment for algae.

When necessary, surface water treatment operations may be required to utilize fabric filter bag staged filtration to meet regulatory standards prior to offsite discharge or to prevent siltation loading on the GAC treatment units. Investigation of commercially available bags showed ratings were not consistent or accurate.¹¹ A test program was therefore initiated using American Society for Testing and Materials (ASTM) procedures.¹² Suppliers of superior quality bags have been identified.

4.1.2 Future Work

Efforts will continue to improve surface water filtration operation for better efficiency, predictability and reliability. Evaluation of filter cartridges, compatible with the existing RFP

¹⁰ E. J. Moritz and J. Olthof, Microstrainer Pilot Testing of Rocky Flats Plant Terminal Ponds A-4, B-5, and C-2, SWD-011-92, September 1992

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equipment, will be conducted in calendar year 1993. Additionally, a contract will be in place by February 1993 to start pilot-scale testing of multi-media/sand filtration equipment.

4.2 CHARACTERIZING RADIONUCLIDES

Radionuclide characterization is a multiyear program aimed at determining the physical and chemical forms of waterborne radionuclides in the terminal detention pond waters and the outlet of the Sewage Treatment Plant (STP) at RFP.¹³ (The radionuclides are believed to be associated with small particulates of organic and inorganic colloids in the size range of 50-100 μm .) Included in the study over the period will be determining seasonal variation in the levels of radionuclides and seasonal variation in speciation as to impact on treatability, the impact of storm events and variations among ponds.

4.2.1 Conclusions to Date

Initial work was conducted with Pond C-2 waters. The size distribution of plutonium in Pond C-2 water was evaluated by processing through a series of filters that ranged from 10000-, 450-, and 2-nm effective separation. The results of the particle size distribution. In summary, a variable distribution of plutonium occurs among various size fractions. Most of the plutonium (~60-75 percent) is associated with the greater than 450 nm size fraction. A significant amount is in the soluble (less than 2 nm) size fraction (~17-32 percent). Lesser amounts were found in the soluble fraction. The largest variability exists within the greater than 450 nm size fraction (i.e., between >450 to <10000 nm and >10000 nm).

Tests were conducted to determine chemical variability as an influence in radiochemical variability. The samples were tested for pH, dissolved oxygen, redox potential, total alkalinity, and conductivity. The results suggested that chemical constituent variability cannot be used as an indicator of plutonium variability.

4.2.2 Future Work

Future work in this area, includes the identification of all contributors to the radionuclide determinations in the surface waters.¹⁴ This identification will include an isotopic breakdown of the radioactive elements, specifically plutonium, americium, and uranium. If other radionuclides are detected, isotopic analyses will be performed.

4.3 POTENTIALLY APPLICABLE TECHNOLOGIES: FLOCCULATION/SEDIMENTATION

Allied to existing filtration processes are those processes which use flocculation to increase particle size for enhanced ease of separation. Sorbants can be used in combination with flocculants. Thus, in these processes, colloidal particles can become attached to sorption agents (clays) which become agglomerated by the further addition of polymeric flocculating agents. Sedimentation can then be used as a means of separating the concentrated solids. This is recognized under BAT as coagulation/filtration (C/F).

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- ¹¹ E. J. Moritz, C. R. Hoffman, and T. R. Hergert, *Water Treatment Filter Bag Efficiency, Capacity, and Tensile Testing*, MST92-017, EG&G Rocky Flats Inc., December 1992
- ¹² E. J. Moritz, *Pond A-4 Water Treatment Filter Bag Test Results*, EJM-003-91, EG&G Rocky Flats, Inc., December 1991.
- ¹³ W. L. Polzer and E. H. Essington, *The Physical and Chemical Characterization of Radionuclides in the Surface Waters at Rocky Flats Plant*, Los Alamos National Laboratory report, LA-UR-92-1812, 1992
- ¹⁴ W. L. Polzer and E. H. Essington, *Multi-year Sampling and Characterization Plan*, Los Alamos National Laboratory, LATO-EG&G-91-022, 1991

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A major test program was initiated using actual Pond C-2 water which was spiked with plutonium. The initial test series concluded that the combination of sorbant and freshly prepared CATFLOC provided good separation of plutonium by sedimentation. The best sorbants included kaolinite and Ca-Montmorillonite. Use of enhanced montmorillonite avoids the need for CATFLOC because that functional group is built in to the structure. Plutonium removals were demonstrated to be in the 93-99 percent range for plutonium-239(IV) from 0.3 to 105 pCi/L with 15 minutes of sedimentation time.¹⁵ Optimization studies in the second test series identified particular sorbants and doses. Dosages of 3.8 to 38 mg/L seemed optimal for flocculant under strictly controlled laboratory bench-scale conditions.¹⁶

The effect of temperature over the range 4-40° C on required treatment agent dose was studied in the third test sequence.¹⁷ This temperature range did not adversely affect treatment effectiveness for plutonium. The fourth test series studied treatment for uranium and concluded that the combination of sorption plus flocculation showed removals of up to 55 percent from solutions of 35-36 pCi/L of natural uranium.¹⁸

¹⁵ I. R. Triay, *Report on the Effectiveness of Flocculation for Removal of ²³⁹Pu at Concentrations of 1 pCi/L and 0.1 pCi/L* Los Alamos National Laboratory report, LA-UR-92-1704, 1992

¹⁶ I. R. Triay, G. K. Bayhurst, M. Klein, and A. J. Mitchell, *Report on the Optimization of Experimental Parameters Utilized for Flocculation, RFP Pond Water Characterization and Treatment*, Los Alamos National Laboratory, LATO-EG&G-91-022, 1991

¹⁷ G. K. Bayhurst, M. Klein, and A. J. Mitchell, *Report on the Effects of Temperature and Credible Inhibitors on Flocculation*, Los Alamos National Laboratory, LATO-EG&G-91-022, 1991

¹⁸ I. R. Tray, G. K. Bayhurst, and A. J. Mitchell, *Report on the Effectiveness of Flocculation for Removal of Uranium at Concentrations of Approximately 2 pCi/L*, Los Alamos National Laboratory, LATO-EG&G-91-022, 1991

APPENDIX D
TECHNOLOGY DATA SUMMARIES FOR TREATMENT
TECHNOLOGIES REVIEWED IN FY 92 ANNUAL REPORT

RADIO FREQUENCY HEATING

Description

Radio frequency heating is an innovative technology for volatilizing organic constituents in soils and other contaminated media. It is a desirable in situ treatment since it requires no chemicals or water and does not introduce any substances to the site. The in situ radio frequency (IRF) heating process requires minimal intrusion, with several 3" to 6" diameter boreholes containing antennae strategically placed through the desired volume. Through a combined mechanism of ohmic and dielectric heating, the temperature in the media is raised and the volatile and semivolatile organic constituents are volatilized. The volatilized organics may be permitted to migrate to the surface of the media where they are collected as off-gases or their removal may be enhanced through the use of installed vapor extraction wells. In either case, the off-gas can be treated to remove any hazardous organics.

RF heating has been suggested as a means of separating mixed wastes of organic and radionuclide contaminants. The removal of the organic constituents of mixed wastes significantly reduces the volume of radioactive waste and simplifies the disposal of the individual radioactive and organic waste constituents. Also, since organic contaminants often interfere with stabilization/solidification processes, their removal is necessary if immobilization of the radionuclides is desired. Special waste drum jackets are available from proprietors which enable drummed wastes to be treated by RF heating without risk of human exposure.

Radio frequency heating uses electromagnetic energy radiating through the contaminated media from specially designed antennae (Kasevich, et al., 1992). The resistance of the media to this energy causes it to become heated, which in turn volatilizes contaminant organic molecules. Since the primary mechanism of heating is not thermal conduction but rather radiation, the thermal conductivity and permeability of the media are not the primary factors in heating performance. The governing factor in the successful absorption of electromagnetic energy is the dielectric constant of the media, and most soils have high enough dielectric constants that they are easily heated in this manner. Water is vaporized to steam by the RF energy, but steam is transparent to RF energy and does not continue to absorb energy once vaporized. The steam serves to heat the surrounding materials, aiding in the volatilization of organics. Thus, water within the soil matrix is not a serious hindrance to the treatment, but rather serves to reduce losses due to the matrix dielectric losses. Fractures and voids within the soil matrix are also not significant threats to the treatment method since thermal conduction is not the primary heat transfer mechanism. Densely packed soils are also well suited to this treatment since there is no intrusion required to produce the heating effect. Unlike other in situ treatments, e.g., steam injection, IRF does not require contact with the volume

to achieve heat transfer. The IRF system uses electromagnetic radiation and needs no carrier media and thus easily penetrates rock and dense soils.

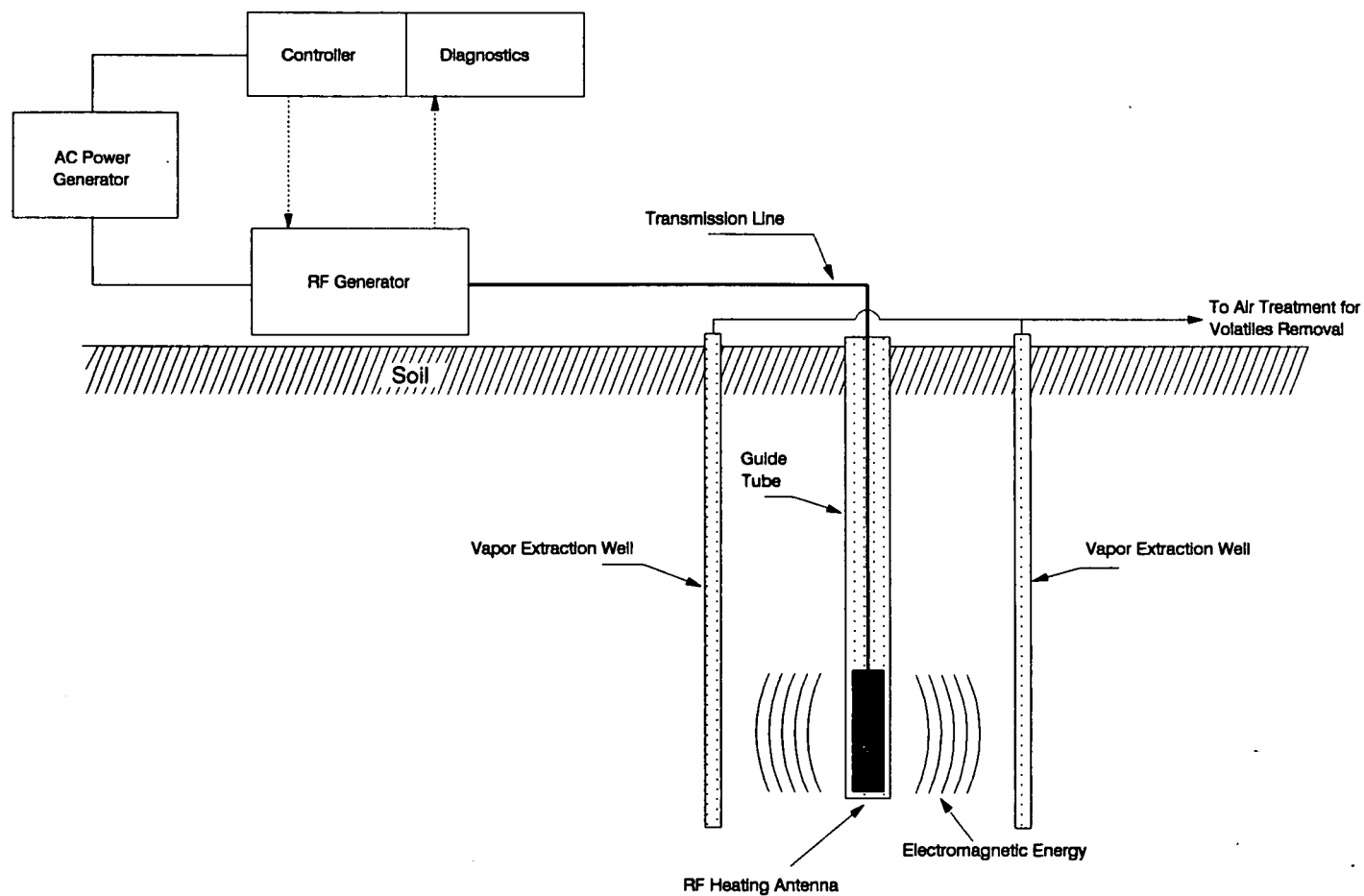
The equipment necessary for this treatment technology is specialized, with the primary equipment unit being the applicator antennae. The antennae are generally flexible components of varying lengths which radiate electromagnetic energy in the form of radio frequency waves. The energy is supplied from radio frequency generators at the surface and transmitted to the antennae via metal coaxial cable. The antennae are placed in boreholes, typically 3" to 6" in diameter, which are made using common drilling equipment. The boreholes are generally cased with fiberglass or a similar material that is transparent to electromagnetic radiation. The antennae can be placed in vertical or horizontal boreholes, depending on the needs at a specific site. Extraction of liquids, if necessary, can be done through the boreholes used for the applicators. Distance between boreholes varies up to 200 meters, depending on local geology. The generators are linked to a control device which monitors performance of the system and adjusts output accordingly. Power for the radio frequency generators is supplied from an alternating current (AC) power source.

The configuration of the radio frequency system is quite flexible, depending on site specific characteristics, remediation goals, and economic constraints. The simplest configuration is a single antenna, which radiates energy in all directions to heat the surrounding volume (Figure D-1). Performance can be optimized by finding the best operating frequency and length of the antenna.

A greater degree of control and a larger overall volume of heating can be achieved through the use of multiple antennae and multiple boreholes, strategically placed to achieve specific goals such as focused or uniform heating. A multiple borehole, phased array system can heat large volumes with a minimal number of boreholes. To achieve uniform heating throughout the desired volume with minimal external disturbance, antennae are precisely positioned and the phase of their output manipulated such that the signals from the various antennae reinforce each other within the volume and cancel each other outside it. Test configurations of four antennae produced nearly uniform heating throughout the desired volume, with somewhat elevated temperatures only at the boreholes themselves and at the midpoints between boreholes. Heating outside the volume was virtually eliminated by the canceling of waves from one antenna by another. Configurations can also be designed to achieve focused heating in specific portions of the volume.

Applications

RF heating is effective for a large number of organic compounds in both saturated and unsaturated soils. The temperature of the soil can be raised to approximately 500 degrees Fahrenheit,



Radio Frequency Heating General Arrangement Diagram

Note: Figure represents information provided in part by KAI Technologies, Inc.

Figure D-1

volatilizing any organics which boil below this temperature. Generally, this limits the treatment to halogenated solvents and petroleum derivatives. Evaluations are under way to determine the effectiveness of the IRF heating process on higher boiling point organics such as PCBs. Viscosities of non-volatile compounds are reduced, increasing mobility and the ease with which they can be pumped out of the ground. Some volatile compounds are pyrolyzed and spontaneously decay to harmless components at the surface, while others are merely volatilized and require further treatment. Off-gas collection and treatment is necessary, requiring a vapor collection system either above or within the contaminated volume.

Very little quantitative information is available as to the effectiveness of this treatment technology at actual contamination sites. The technology is quite innovative and no hard data on real world effectiveness is yet available. Several treatability studies and bench- and full-scale pilot studies are under way at Department of Energy facilities. Once the results of these studies are known, the effectiveness of the IRF heating process on specific contaminants and soil compositions will be much more defined than at present.

Advantages and Disadvantages

The greatest advantage to the use of IRF heating is its ability to treat subsurface soils in situ without significant soil disturbance. Also, IRF heating can be adapted to a wide range of site conditions. Contaminants can be remediated with very little impacts stemming from surface structures and/or subsurface "anomalies" (e.g., buried drums, rock, perched water, etc.). Support treatment requirements can be satisfied easily through conventional treatment technologies such as carbon adsorption.

IRF heating has not, however, been tested or proven under field conditions. Additional testing and research is required in order to fully determine the potential advantages and disadvantages of this type of in situ remediation technology.

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MANGANESE DIOXIDE ADSORPTION

Description

Manganese dioxide adsorption is considered primarily for the isolation of radionuclides from aqueous streams. The chemical adsorption properties of manganese dioxide have been well documented. Morgan and Stumm (1964) characterized the sorption mechanics of common bivalent cations by hydrous manganese oxides (HMOs), and other investigators including Posselt, et al (1968), Loganathan and Burau (1973), and Smith and Jenne (1991) have documented the sorption of heavy metal ions and calculated surface complexation constants for the adsorption of metal by HMOs. The adsorption behavior of 61 radioactive ions on specially prepared MnO_2 was investigated by Bigliocca, et al. (1967). These studies revealed no definite trends in the sorptive properties of manganese dioxide among elements of similar chemical behavior, but potential applications in the field of radionuclide separations were described.

Valentine, et al, (1990) demonstrated the effective removal of radium ($^{226}\text{Ra} + ^{228}\text{Ra}$) by HMO adsorption from drinking water supplies. During pilot-plant studies, suspensions of freshly precipitated MnO_2 were fed into natural raw water supplies at dosages ranging from 0.5 to 1.0 mg/L as Mn prior to filtration. Initial radium activities ranged from approximately 3 to 17 pCi/L. The isotherm for radium removal was shown to be linear over the concentration ranges investigated. Effluent ^{226}Ra activities ranging from 0.5 to 1.0 pCi/L were achieved resulting in removal efficiencies ranging from 65 to 85 percent. The method of HMO preparation was shown to be an important dependent variable in radium removal efficiencies. Higher removal rates were achieved at lower cost when the MnO_2 was prepared by permanganate oxidation of Mn^{+2} ions. The pilot plant was designed as a standard water filtration plant with no additional equipment required for radium removal.

Isotherm data for other radionuclides such as plutonium are not reported in the literature; and the potential for adsorption of these elements cannot be inferred from the successful removal of radium in drinking water as shown by Bigliocca, et al (1967). Studies thus far have been conducted at low ionic strengths and the effect of competing ions on radionuclide separations has not been addressed adequately enough in the literature to properly evaluate the technology. The possible preferential adsorption of competing ions (over radionuclides) needs to be investigated.

Applications

The effectiveness of radionuclide separation by HMO adsorption has not been extensively documented, and most of the basic research on manganese dioxide adsorption has been conducted on solutions of relatively low ionic strength. This technology was proven effective in the removal of radium (^{226}Ra) at low activity levels from natural waters. This technology is also applicable as a potential method for reducing the radionuclide activity of aqueous wastes. However, the effectiveness of this technology as a pretreatment or effluent polishing process in conjunction with other primary treatment technologies is uncertain; and research would be required to determine its potential applicability. Treatability studies would be required to adequately judge the potential effectiveness of this technology for a given waste stream and provide data on residuals generation.

Advantages and Disadvantages

The full scope of implementing HMO adsorption for treatment of radionuclide bearing wastes is uncertain. This technology appeared to be readily implementable for drinking water applications; however, the possible technical problems associated with treatment of high ionic strength wastes have not been investigated. Interference from competing ions for adsorption sites and the very low solubility of many radioactive compounds in aqueous solutions are possible technical problems. Bench- and pilot-scale treatability studies would be required to fully assess the technical implementability of this technology at a specific waste site.

If no technical problems associated with the adsorption chemistry of the wastes are revealed during treatability studies, this technology would be readily implementable as a pretreatment or effluent polishing process in conjunction with other treatment technologies for the removal of radionuclides from aqueous waste. A reliable offsite source of freshly precipitated MnO_2 may be difficult to procure, but this material could be produced onsite by a skilled technician with the proper chemical mixing equipment. A key disadvantage to HMO adsorption technology is the need for rehydration of solid wastes which would increase the mobility of the waste and potential for release to the environment during the remediation.

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REVERSE-BURN GASIFICATION

Description

Reverse-burn gasification is a thermochemical process which can be used to thermally destroy a variety of waste materials. The reverse-burn gasification process offers a number of advantages over conventional incineration processes, and can be used to treat wastes in the forms of solids, liquids, sludges, and soils. The process destroys wastes by converting it to a combustible gas and a dry, inert, carbonaceous solid (ash). This ash may be disposed of directly in a non-hazardous waste landfill or may require further treatment, e.g., solidification, if hazardous constituents such as heavy metals and/or radionuclides remain in the ash prior to disposal. The reverse-burn gasification process is particularly effective at treating organic waste sludges which also contain heavy metals and/or radioactive substances. At this time the process has been tested in a laboratory setting, but has not been implemented on a full or pilot scale basis. Results referred to in this technology review are from experimental laboratory testing of the process on various input waste streams.

The reverse-burn gasification process is advantageous over conventional incineration processes in that it produces a combustible gas which is burned in the treatment instead of an exhaust gas which must be treated to control emissions. The waste destruction is a two-stage process: gasification followed by combustion of the gas. Combined, these two stages lead to a destruction of the wastes at levels exceeding the six nines (99.9999%) standard for thermal destruction processes.

At this time in the development of the process, only a batch mode version of the reactor is available. For the gasification process, the batch reactor is charged with a granular solid (char) which contains combustible matter. Water, present on the solid char or introduced as steam into the reactor, is required for the process as a source of hydrogen for waste-destroying reactions. Oxygen, air, or compressed air is added and a flame front is initiated by heating the solid material in the reactor. This flame front moves in a direction opposite to the flow of gas at temperatures in excess of 1200 degrees C. Three reactions occur across the flame front as it moves through the reactor: oxidation at the leading edge, volatilization and pyrolysis in the middle of the flame front, and reduction in the trailing edge. After the flame front has passed through the solid material, a solid carbon product remains from which water and volatile organic matter have been removed. The solid residue retains heavy metals and acid gases (HCl) if the original solid material was alkaline.

Testing completed to date has primarily focused on the use of a subbituminous coal material as the granular char matrix. The subbituminous coal is a non-swelling, low-sulfur, high alkalinity fuel that produces a char with the characteristics needed for waste treatment. The coal is converted to char by three consecutive reverse-burn gasification runs in the reactor cell. This type of char is called triple-reverse-burn (TRB) and is a highly porous material capable of absorbing large amounts of waste liquids or sludges. In essence the char is a low grade activated carbon which is ready to receive wastes prior to initiating the treatment process. The TRB char provides a relatively uniform support for the loaded wastes and allows for a uniform passage of gases. The carbonaceous matrix also provides a chemically reducing medium and a source of hydrogen required for dehydrohalogenation.

In normal practice, gasification would occur on wastes which are immobilized on a char matrix. Some types of wastes, such as granular soil containing combustible matter, can be gasified directly without the char substrate. But in most cases, the use of a char base is preferred as it improves the efficiency of the gasification process. Liquid wastes can be directly sorbed onto the char surface; aqueous wastes can be filtered through a bed of char to remove hazardous materials. The resulting purified water can be discharged (the char in essence acts as a carbon filter for aqueous waste). Solid wastes can be macerated and mixed directly with the char before introduction into the reactor chamber. The gasification of the waste-char mixture can be accomplished in the same reactor which is used to produce the TRB char. In the operation of the process, the gas product from the gasification of the char-waste matrix undergoes combustion to provide energy recovery and destroy any residual impurities in the gas. This enables the achievement of destruction in excess of 99.9999%. Any aqueous condensate generated during the process can be recycled to the process to provide makeup water for the waste destruction and enable destruction of wastes in the condensate. Following the reverse-burn gasification run, the remaining char matrix is removed from the reaction cell and can be disposed of in a landfill or other disposal unit. If the char residue contains heavy metals or other hazardous constituents, additional conventional treatment such as solidification may be required.

Applications

The reverse-burn gasification process can be used to destroy organic contaminants in several different types of wastes. The best application for the process is the destruction/treatment of chemical waste sludges, particularly those which contain refractory organic compounds, such as PCBs. These wastes commonly also contain heavy metals, which do not interfere with the treatment process. The process effectively destroys the organic wastes and dehydrohalogenates the organohalides. The char matrix will retain any metals present after the burn process.

In addition to chemical waste sludges, the process can be used to treat soil contaminated with combustible organic matter (such as petroleum contaminated soils). After the reverse-burn gasification step, the soil can be converted to a stable fused material by running the gasification process in the forward direction. This additional step will tend to bind any metals present in the waste into a stable fused mass.

Sewage sludge from municipal wastewater treatment plants can also be treated by the reverse-burn gasification process. The sludge is converted into a combustible gas and a char residue by the process. The gas can be burned to provide energy for the process, and the residue can be mixed with additional sludge for drying and conditioning prior to a round of treatment by gasification.

A promising area of application for the process is treatment of mixed wastes (radioactive substances and organic substances). Reverse-burn gasification of mixed waste results in the destruction of organic substances while radionuclides are retained in the char matrix. Subsequent forward-burn gasification of the char residue can be used to immobilize radioactive wastes in a generated slag which can have a volume as low as a few percent of the mixed waste feedstock volume. This process not only destroys the organic content of the waste, but also serves to reduce the volume of radioactive waste which requires final disposal.

The reverse-burn gasification process can also be used to regenerate spent activated carbon used to treat aqueous liquids which contain organic contaminants. The sorptive properties of the carbon are restored by the reverse-burn process. If any heavy metals are present on the carbon prior to regeneration, they will remain on the carbon after the gasification process.

Advantages and Disadvantages

The greatest advantage to using reverse-burn gasification as a technology for the treatment of hazardous waste is that it provides for the destruction of the organic constituents present. The gasification process, in contrast to conventional incineration, is advantageous with respect to emissions. Also, gasification operates under reducing conditions and produces a combustible gas that can be burned very efficiently under controlled conditions to destroy any remaining traces of wastes or gasification products. The process is also particularly effective at dehydrohalogenating refractory organohalide compounds without producing oxygenated organohalides, particularly chlorinated compounds that are often more toxic than the original compound being treated. Conventional incineration often experiences these types of toxic by-product problems. Also, the residual char after gasification effectively retains metals, acid gases, and residual organic matter in a stable form. The process has been shown in the laboratory to destroy organic compounds to

levels greater than 99.9999% without the production of undesirable by-products, and without the evolution of significant amounts of hydrogen chloride.

The greatest disadvantage associated with the reverse-burn gasification technology is that it is still in the development phase and has not been proven on a pilot or commercial scale. The test process developed to date is a batch process, which is less desirable than a continuous process when processing large volumes of wastes. Cost data for construction and operation of the process has not yet been developed. It is anticipated that costs for this type of process will be comparable to costs associated with conventional incineration of hazardous organic wastes.

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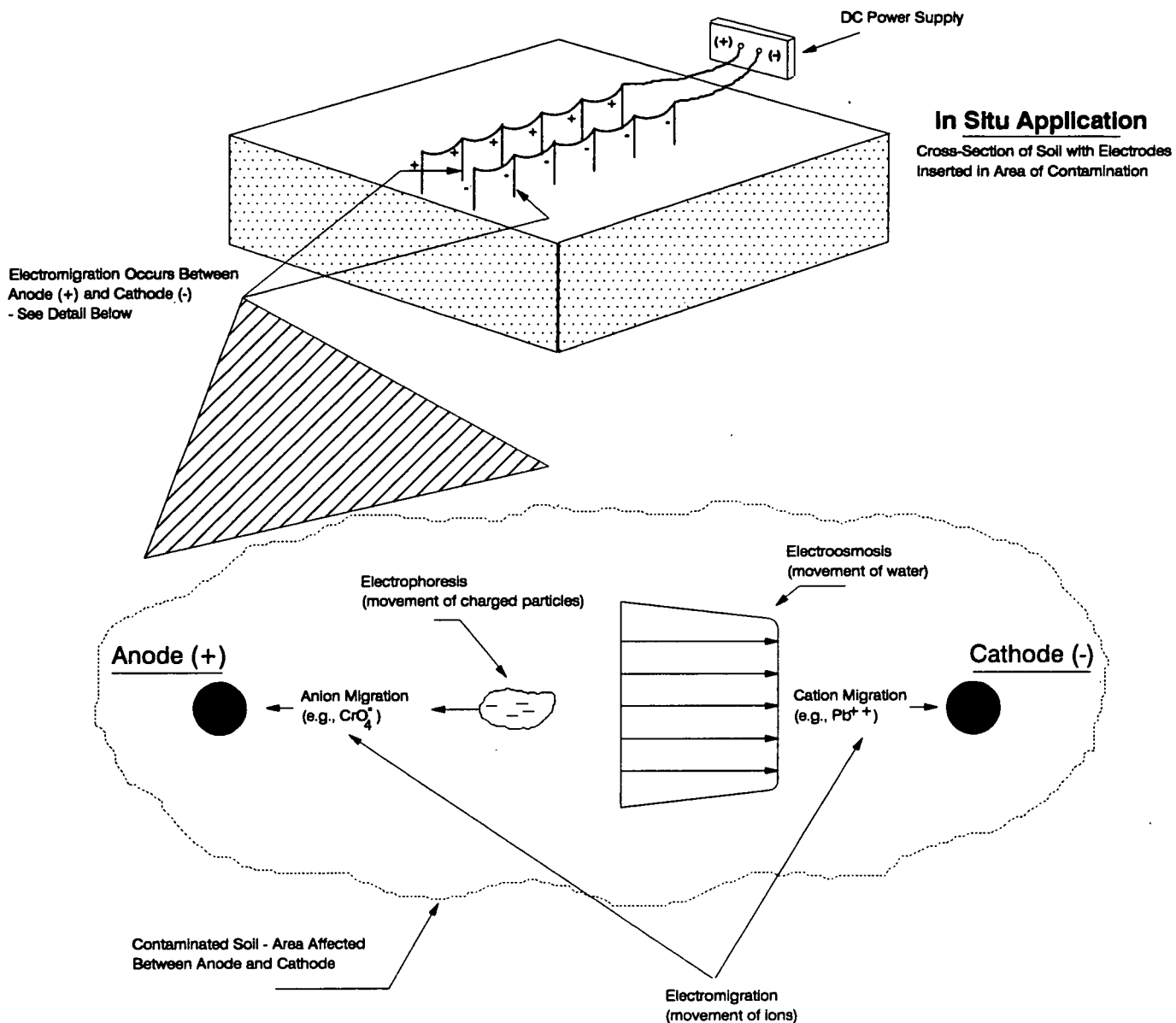
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Description

Electrokinetic remediation is a treatment process for heavy metal contaminated soils whereby electrodes are implanted in the soil to be treated, and a direct current is imposed between the two electrodes. The application of the direct current produces a number of effects: any ionic species and other charged particles present in the soil will migrate to the oppositely charged electrode (electrochemical processes known as electromigration and electrophoresis), while a bulk flow of water is induced toward the cathode (known as electroosmosis). Figure D-2 shows a simple configuration for the in situ application of electrokinetic remediation, and a simple representation of the migration phenomena present in soils undergoing treatment. The direction of contaminant movement is determined by several factors, including the type and concentration of the contaminant, the soil type and structure, the interfacial chemistry of the soil-pore water system, and the current density in the soil pore water. Once the contaminants have been moved from the soil to one of the two electrodes, several methods may be used to remove the contaminants from the system. These methods include electroplating on the electrode, precipitation or co-precipitation of any generated solution, or removal through a process such as ion exchange.

Electrokinetic remediation has also been referred to as selective electrochemical migration by several researchers active in investigating the applicability of the technology to heavy metal contaminated soils. In one experimental electrokinetic remediation system, the collector electrode (cathode for cations, or anode for anions) is surrounded by a porous material designed to provide a liquid reservoir that is separate from the soil to be treated. The driving electrode (anode for cations, or cathode for anions) is surrounded by a permeable membrane which passes only the ions of the same charge as the contaminant ions to be collected. The driver electrode compartment contains a solution which provides free driver ions which migrate through the permeable membrane and carry the electric current. This driver solution consists of cations for cation collection and anions for anion collection. In the design of an electrokinetic remediation system, the driver solution ions are selected such that they will displace the contaminant ions in the soil column as they enter the contaminated soil. Then the contaminant ions will continue to carry the electric current to the collection electrode. Once the contaminant ions reach the collector electrode, they can be removed from the soil column by one of the techniques referred to above.

The literature for electrokinetic remediation indicates that experimental level work has been done with this technology for soils contaminated with chromium, mercury, and uranium. These contaminants have been studied due to their widespread occurrence at U.S. Department of Energy



Electrokinetic Remediation General Arrangement and Migration Characteristics

Note: Figure represents information provided in part by (Lindgren, 1991)

Figure D-2

and U.S. Department of Defense sites. Bench scale treatability testing has been completed using this technology for chromium contaminated soils from the Sandia National Laboratories (SNL)(Lindgren, et al. 1991). The experimental program at SNL is directed toward determining the feasibility of in situ remediation of a chromium in soil plume using the electrokinetic process. This particular treatability program evaluated the effectiveness of electromigration of chromate ions versus a dye analog. The dye analog was used as a predictor of chromate migration performance since it is easier and less costly to visually track the movement of the analog dye through an experimental soil column. It should be noted that the soils tested at SNL were similar to native soils of the region (sandy texture). For this experimental work, a plastic test cell was packed with native sands in a manner to reflect in situ conditions. Two graphite electrodes were placed in the test cell to function as collector and driver electrodes. Pure red dye was used in the test runs in a dye concentration equivalent on a molar basis to 100 ppm Cr. Researchers indicate that the dye analog will move through soil in a manner that closely resembles the movement of chromate. In addition, this study included trials using a test cell spiked with chromium. In order to measure the effectiveness of the technology on the chromium containing soils, the test cell was destructively sampled and analyzed for water soluble chromium and moisture content following completion of the test runs.

The results of this experimental testing indicated that electromigration of chromate ions in unsaturated sands is possible. During testing, the initial region of sand contaminated with chromate ions was completely cleansed of contamination. The chromium migrated at an average velocity of 0.4 cm/hr, while the counteracting velocity of pore water by electroosmosis was considerably lower. This result indicates that electromigration is the dominate transport mechanism in operation. For the dye analog tests, the migration rates noted were less than the rates for the chromate runs. However, on a qualitative basis, the results were very similar to the chromate run. Thus, the dye is a good analog for the study of chromate movement through soils. The use of the dye as an analog greatly accelerates experimentation since destructive sampling is not required to track/monitor the location of the contaminant as treatment progresses.

Additional research focused toward the recovery of mercury and uranium from contaminated soils. For mercury, two sets of experimental runs were conducted, one utilizing hydrogen as the driver ion solution, and the other using sodium as the driver ion solution. Both sets of trials were successful at transporting the mercury through the soil test column. For the hydrogen driver runs, all of the mercury was either in solution or deposited on the cathode at the completion of the experiment. For the sodium driver runs, the mercury was either deposited in the cathode or present in the form of a dark precipitate. In both cases, all of the mercury was removed from the initial contaminated soil. Optimization of an electrokinetic remediation system for mercury could lead to increased migration rates for the contaminant as well as increases in the percentage of mercury present in any precipitate formed (important for waste management considerations). The

testing completed for uranium contaminated soils by the same researcher yielded similar results.

It is anticipated that a field electrokinetic remediation installation would consist of an array of electrodes installed approximately three (3) meters on center and to a depth approximately one meter deeper than any detected contamination. To date, bench-scale testing has been completed only on sandy textured soils and it is uncertain how the technology would perform on other soil types (i.e., more fine grained or clay soils).

One researcher has estimated that the cost of application of electrokinetic remediation will range from \$200 to \$250 per cubic meter of soil treated. This cost range is dependent on the area to be treated, the depth of treatment, and the specific contaminant and concentration to be treated. This cost is moderate when compared to other treatment technologies for heavy metals, but it should be noted that this technology is in situ and does not require expensive excavation/removal measures prior to treatment. These costs also do not address any further handling/treatment/disposal of generated residuals (precipitates, etc.) which may be required.

Applications

Electrokinetic remediation is conceivably applicable to any ionic contaminant which may be present in a soil; however, bench-scale testing of the technology to date has been limited to chromium, mercury, and uranium. Limited studies have indicated some success at mobilizing benzene, toluene, ethylene, and xylene in gasoline as well as trichloroethylene at concentrations below their solubility limits (Acar, 1992). The technology can be applied either in situ or ex situ on excavated soils. At this time, the technology is considered "emerging" and has not been tested on a field scale. Given the large number of hazardous waste sites in the U.S. which contain heavy metal contamination and are difficult to access for removal/treatment/disposal, electrokinetic remediation may be applicable to numerous sites should it be proven viable on a pilot scale.

Advantages and Disadvantages

The greatest advantage of the electrokinetic remediation process is the ability to apply the technology in situ. This allows contaminants to be remediated from below physical structures without impact to the structures. Also, the technology is a removal process as opposed to an in situ stabilization process. Several other comparable in situ processes immobilize soil contaminants in place but do not remove the contaminants from the environment. In theory, the process is also

applicable for any ionic contaminant present in a soil; although to date, the process has been tested only for a few selected contaminants.

Electrokinetic remediation is a new and emerging technology, and in that respect has not been tested or proven in field contamination settings. Only additional testing and evaluation of the technology will prove its effectiveness and applicability to actual hazardous waste sites.

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EXTRACTION OF CHELATED PLUTONIUM USING SUPERCRITICAL CARBON DIOXIDE

Description

Supercritical fluids can be used in extraction techniques that target specific metals and radionuclides, and are effective in matrices that would normally be too complex for solvent extractions, e.g., contaminated soil. The use of supercritical carbon dioxide for desorption of fixed bed adsorbent particles such as GAC has been investigated, and the results can be applied to the extraction of contaminants from soils in which the organic affinities tend to be much less than those of GAC.

The use of chelating agents (see description below) dissolved in supercritical carbon dioxide is a method of removing metals and radionuclides from complex matrices. Extraction of organics using carbon dioxide is enhanced by increasing the pressure above carbon dioxide's critical point. At this pressure carbon dioxide exhibits the high density and solubilizing power of a fluid and the high diffusivity and low viscosity of a gas. Tan and Liou (1988a, and 1988b) studied the desorption of activated carbon with supercritical carbon dioxide and defined the optimal temperature and pressure to be 313 Kelvin and 10.13 megapascal (1470 psi). The process occurs continuously but is actually three separate reactions. First, organic ligands with multiple bonding sites (i.e., chelating agents) are dissolved in supercritical carbon dioxide and passed over a soil sample containing metal contaminants (e.g., plutonium). Second, as the solution contacts the metal ions, bonds are formed between the ions and the chelating agents to form a metal-organic complex. Third, since the chelating agents themselves are dissolved in the carbon dioxide, the entire complex is dissolved in the supercritical carbon dioxide.

After the chelating agent-metal ion complex has been removed from the reactor, the pressure can then be reduced causing the metal- and chelating agent-bearing solution to vaporize. The chelated metal can then be recovered from the solvent vapor by filtration. Solids can then be redissolved in an organic solvent and the resulting concentrate contacted with water to partition the contaminant into the water. Solvent vapor can be recompressed and used again.

Organic chemicals with the ability to bind to metals at more than one point are known as chelating agents. Chelating agents can be designed so that they preferentially sequester specific metal ions. Tang and Wai (1989) reported selectivity of crown ether complexes for lanthanide metals which were adjusted by the addition of a lipophilic branch to the macrocyclic polyether. Specifically, chelating agents can be chosen so that they are selective in nature to bind with plutonium. Addition of functional groups to organic chelating complexes can further adjust the selectivity of

the molecule by changing its size and character. Functional group addition can also affect the solubility of the chelating agent. For extraction to be completed, the chelating agent-metal complex must be soluble in supercritical carbon dioxide. The solubility of the complex in carbon dioxide is critical in describing extraction efficiency. Other factors that affect the efficiency include pH and solvent type.

Organics have variable solubility in supercritical carbon dioxide, and this property can be enhanced by addition of solvents such as methanol. Solubility of the chelating agents in carbon dioxide can also be improved using co-solvents such as methanol. Improvement in solubility in this manner is called entraining. The entrainer effect is caused by chemical association between the co-solvent and the solute (Walsh 1987). Examples of entrainers for use with carbon dioxide are methanol and ethanol.

Equipment needed to perform supercritical extraction includes extraction columns constructed from material resistant to leakage under pressure, as well as an inlet and outlet vessel in which the pressure can be adjusted to supercritical levels. The extraction can be run at room temperature. An apparatus for combining the entrainer with the solvent and the chelating agent must also be constructed. After the extraction from the soil is complete, a vessel for solvent extraction of the metal-chelate complex from the supercritical solution is also needed, as well as a recycle system for the carbon dioxide.

Applications

The application of this technology includes chelation of a variety of metals from solid matrices such as mineral salts or soils. The related application of supercritical oxidation for the destruction of organic contamination is also promising because it allows the destruction of compounds at low temperatures that normally require large amounts of heat at standard pressures.

Advantages and Disadvantages

The major advantage associated with supercritical carbon dioxide is that the process is both inexpensive and readily available. If the system apparatus is designed properly the solvent is also reusable.

The disadvantage associated with this technology is that the process may be difficult to scale up effectively. Since it is not an in situ treatment, columns would have to be loaded routinely, thus increasing the risk of worker exposure to contaminants and the associated costs of protection.

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APPENDIX E
STATEMENT OF WORK FOR SELECTED TECHNOLOGY

RADIO FREQUENCY HEATING SCOPE OF WORK FOR TREATABILITY TESTING

In situ radio frequency (RF) heating was selected as a potentially applicable remedial technology for soils contaminated with VOCs and SVOCs at the RFP. Laboratory bench-scale treatability testing was recommended to better evaluate this technology with respect to its site-specific effectiveness and implementability. The following sections detail information and procedures related to the laboratory evaluation of RF heating. If RF treatability tests are performed, detailed procedures will be completed at a later date and provided to the appropriate EG&G-RF personnel for review.

Technology Description

The in situ RF heating technology uses electromagnetic wave energy (radio frequency) in the range of 2 to 45 megahertz to heat soil. Radio frequency is an efficient and cost-effective method of heating the soil without excavation. The RF process removes VOCs from the soil through the primary mechanisms of vaporization, distillation, and steam stripping.

The RF process has been under development since the mid-1970's. The process was originally developed for the recovery of hydrocarbons by in situ heating of large volumes of soil. The RF process has successfully heated large volumes of soil to temperatures in excess of 725 degrees F. The process has been used successfully to heat tar sands at depths of more than 100 ft to enhance the recovery of oil from the sands.

The RF heating method differs from conventional forms of dielectric heating in that this approach uses antenna technology to radiate electromagnetic energy into a material surrounding the antenna. The electromagnetic energy transfer causes heating at the molecular level throughout the material without the need for conductive or convective heat transfer mechanisms. Therefore, the thermal conductivity or permeability of the soils are not governing factors for effective heating of a material by electromagnetic energy. For the RF heating process, the complex dielectric constant of the material is the fundamental electrical parameter that defines the ability of the material to acquire heat by electromagnetic absorption. Moist soils and hydrocarbon sludges are materials which can be easily heated in this manner.

In RF heating, materials are dielectrically heated to release vapors, to reduce viscosity, and to drive chemical reactions. Therefore, the effect of the heating process can be controlled to release volatile liquids from soils. The simplest RF application will utilize a single antenna or applicator in a single well in the material to apply heat. For more highly controlled and directed heating

requirements the applicators can be used in arrays of two or more antennas. The input power to each element can be controlled to provide near uniform or focused heating. Arrays configured for focused heating can be dynamically controlled by phase steering techniques. Timed power applications systems can be designed and installed to provide for a slow thermal mixing of the material.

A more detailed description of RF heating, including figures, can be found in Appendix D of the FY 92 Annual Report.

Type of Treatability Study

The laboratory studies outlined below are intended to meet the following treatability testing objectives:

- To evaluate RF heating techniques with respect to site-specific in situ conditions;
- To obtain the data necessary to estimate the RF system design configuration required to achieve treatment objectives;

The volatile organic constituents detected in soils at the RFP are amenable to RF heating techniques in that they will become volatilized with the application of heat to the soil matrix. Therefore, the focus of this treatability study for RF heating is the evaluation of the soils with respect to critical RF heating parameters as defined below. Therefore, the RF treatability study is not intended to test the fate of individual compounds under heating conditions. Instead, proof-of-concept will be judged based on estimates of energy and heating required to achieve optimal temperature conditions to effectively implement the technology in an in situ setting.

Parameters to be Tested and Soil Sample Size

The following treatability testing methodology was suggested by KAI Technologies, Inc. of Woburn, MA (contact: Julianne Kallas, Director of Marketing, 617-932-3328). The methodology focuses on laboratory tests to determine:

- Dielectric lossiness of soil
- Ability of RF Heating to volatilize contaminants

- Design criteria for applicator heads of a pilot-scale unit for potential pilot-scale testing to be performed based on success of lab tests.

A report from the laboratory performing treatability tests on RF Heating should include:

- Temperatures required to heat VOCs and SVOCs
- Performance ranges of the RF Heating system
- Approximation of utility requirements if scaled up from requirements of lab tests

The laboratory treatability tests for RF Heating as described above would require a 5 to 10-gallon sample of contaminated soil from the RFP. The cost of such a treatability test would be approximately \$5,000 for sampling at the RFP and approximately \$10,000 for laboratory analysis and reporting.